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THIRTIETH ANNUAL REPORT

OF THE

COMMISSIONERS OF INLAND FISHERIES,

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MADE TO THE

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AT ITS

JANUARY SESSION, 1900.

PROVIDENCE:
E. L. FREEMAN & SONS, PRINTERS TO THE STATE.
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COMMISSIONERS OF INLAND FISHERIES OF RHODE ISLAND.

J. M. K. SOUTHWICK, *President*	Newport, R. I.
HENRY T. ROOT, *Treasurer*	Providence, R. I.
WM. P. MORTON, *Secretary*	P. O. Box 966, Providence, R. I.
CHAS. W. WILLARD	Westerly, R. I.
ADELBERT D. ROBERTS	P. O. Box 264, Woonsocket, R. I.
HERMON C. BUMPUS, Ph. D	Brown University.

REPORT.

To the Honorable the General Assembly of the State of Rhode Island and Providence Plantations, at its January Session, 1900:

The Commissioners of Inland Fisheries herewith present their annual report for the year 1899:

The work undertaken by the commissioners during the past year, may be tabulated as follows:

First. The stocking of our ponds and streams with suitable fresh-water fish, through the distribution of eggs and fry.

Second. The collection of definite data respecting the times of arrival and departure of various food-fishes, and the preparation of statistics of exportation.

Third. A continuation of the observations on the breeding periods of native marine animals.

Fourth. The location of fish-traps within the waters of Narraganset Bay, and the collection of statistical data bearing upon their ownership.

Fifth. Observations to show the influence, if any, that trap-fishing may have upon line-fishing.

Sixth. The continued examination of the physical and biological conditions of the waters of the Bay, begun in 1898.

Seventh. Experiments to test the feasibility of clam culture.

Eighth. A preliminary survey of the shores of the Bay, for the purpose of determining those portions which in the past were productive clam beds.

Ninth. An investigation of the life-habits of the clam, its breeding period, its food, its rate of growth, its natural enemies, and experiments to test the feasibility of artificial propagation.

Tenth. Continued work on the off-shore fisheries.

Eleventh. Efforts at lobster culture.

Twelfth. Distribution of lobster fry.

Thirteenth. The preparation of a list of the fishes known to inhabit the bay.

Fourteenth. A list of the diatoms found in the water over the clam, mussel, and oyster beds.

These subjects are treated in the above order in the present report, and in view of the results thus far obtained the Commission does not hesitate to ask for a small naphtha launch, and a new floating laboratory, both of which are absolutely essential to the efficient prosecution of their work.

A great deal of time has been lost during the past year in rowing or sailing about, often against head winds and currents; and since the greater amount of shore work must be done during the few hours of low tide, it is necessary to have the means of moving rapidly from place to place. It is the plan of the Commission to purchase a launch of such size that it can be easily cared for by one man, thus making the appointment of extra help unnecessary. Such a boat can be purchased for about $900, and the expense attending its maintenance will be inconsiderable. The work of the Commission has for some years been carried on in the small floating laboratory originally designed for hatching lobsters, and located in the Kickemuit River. On this structure, which is really little more than a fish-car, there has been scant room for one worker, no means of providing heat during the cold weather, and the floats have been so poorly constructed that not infrequently the whole boat, laboratory and equipment, has sunk. In the spring of 1899 it was important that the Commission should have more room for its work, and it seemed desirable to extend the biological observations to the west side of the Bay. As a temporary expedient an old scow was purchased, and upon this a small house was built, largely out of waste material given by the University, several students assisting in the construction. The scow was towed to Wickford on May 1st, where it has since remained. It is a miserable old craft, a disgrace to the State, and now beached to prevent its sinking; but the scientific work that it has enabled the Commission to carry on has far more than paid for its construction and the annoyance of its maintenance. Moreover, it has proved that a house-boat is the most practical design for a shore laboratory, and that it affords the most convenient means for carrying on the work of artificially increasing the marine products of the Bay.

Your Commission has inquired into the probable cost of constructing a suitable floating laboratory, and finds that a house 10 x 10, supported upon two pontoons each 50 ft. in length and giving a breadth of beam of 16 ft., can be built and equipped for about $1,000. Such a structure, enclosing an open well 46 ft. in length, and 8 ft. in width, will serve not alone for investigation, but will make an excellent hatchery in which millions of eggs now annually wasted may be artificially hatched, and it will also provide appropriate enclosures for partially rearing lobster fry.

The properties that have come into the possession of the Commission, and that are now in its custody, are not inconsiderable. There is a small open sailboat, 15 ft. in length, purchased in 1899, and two small skiffs, one at the Kickemuit, the other at Wickford. All these boats are in excellent repair. The small laboratory at the Kickemuit is provided with instruments, glassware, collecting sieves, nets, fish-cars, and implements for work along shore; and the larger scow at Wickford is equipped with mooring chains, two heavy mushroom anchors, a complete camping outfit, laboratory glassware, instruments, and the more ordinary pieces of collecting and retaining apparatus.

The receipts and disbursements of the Commission have been as follows:

State of Rhode Island in Account with Commissioners of Inland Fisheries.

1898.	Dr.	
Dec. 31.	To balance due Commissioners	$37 50
1899.		
Aug. 27.	To paid for 20,000 yearling trout	669 14
Dec. 31.	To paid for investigating star-fish, flat-fish, clams, and lobsters, including house-boat	1,537 24
	To paid for expenses of Commissioners	496 63
	To paid for boat	75 00
		$2,815 51

1899.	Cr.	
May 30.	By cash of State Treasurer	$396 26
	“ “ “	37 50
	“ “ “	7 10
	“ “ “	134 68
July 3.	“ “ “	50 44
	“ “ “	46 44
	“ “ “	200 00
24.	“ “ “	35 00
	“ “ “	30 00
27.	“ “ “	94 18
	“ “ “	120 30
	“ “ “	47 88
	“ “ “	47 35
Aug. 29.	“ “ “	49 71
Sept. 8.	“ “ “	60 00
Oct. 31.	“ “ “	88 44
	“ “ “	9 00
	“ “ “	8 05
	“ “ “	150 00
	“ “ “	60 00
	“ “ “	62 91
Dec. 27.	“ “ “	600 00
	“ “ “	6 10

1899.	Cr.	
Dec. 31.	By cash of State Treasurer	$32 60
	Balance due Commissioners	441 57
		$2,815 51

J. M. K. SOUTHWICK,
HENRY T. ROOT,
CHAS. W. WILLARD,
WM. P. MORTON,
ADELBERT S. ROBERTS,
HERMON C. BUMPUS,
Commissioners of Inland Fisheries.

1. The Stocking of our Ponds and Streams with Suitable Fresh-water Fish, Through the Distribution of Eggs and Fry.

Brook Trout.

During the past year the Commissioners have purchased 20,000 yearling trout and, with the assistance of anglers interested in the restocking of the streams, we have been enabled to distribute these young throughout the State. Although the streams have been unusually low during the open season, many excellent catches have been reported.

The success attending the work of the commission in restocking depleted streams has been very gratifying. Reports from all parts of the State show a large increase in numbers caught by fishermen. It was reported on good authority that hundreds of pounds of trout were taken from Tomaquog River in the town of Hopkinton, in a stream which a few years ago was nearly, if not quite, barren.

Large-mouthed Black Bass.

The efforts of the commission during the past three years to introduce this species into the waters of the State seem to have been successful. In all waters where they have been placed, specimens have been seen or caught that have shown rapid growth. Through the courtesy of the U. S. Commission, two thousand fry were received during the past season, and distributed as follows:

Richmond Pond	400
One Hundred Acre Pond	500
Pawcatuck River	100
Roger Williams Lake	1,000

Small-mouthed Black Bass.

The fishing for this species has been exceptionally good, particularly in Watchaug Lake, where the fish taken have averaged much larger than in several years past. Three hundred fry were received from the U. S. Fish Commission, and liberated in Pasquiset Pond, Washington County. It is the aim of the commission to introduce, as rapidly as possible, both species of black bass into all waters of the State not already stocked.

Land-locked Salmon.

The introduction of this valuable food and game fish is still largely experimental. The method adopted thus far has been to place the young fish in the waters of Mill Brook, a tributary to Watchaug Lake, in the town of Charlestown, where, with protection, they might grow until of sufficient size to enter the deeper waters of the Lake. Although no fish have thus far been caught in the lake proper, several mature fish have been seen in the Pawcatuck River, into which this lake empties through Poquiant Brook. Fifteen thousand fry were placed in Mill Brook in May, 1899. The United States Commission has kindly promised twenty thousand eggs for 1900, which will be hatched by the American Fish Culture Company, at Carolina, R. I., and will be reared by them until eight months old, when they will be distributed in Mill Brook and other suitable waters.

2. The Collection of Definite Data Respecting the Times of Arrival and Departure of Various Food-Fishes, and the Statistics of Exportation.

It has been almost impossible, because of the difficulty of moving from place to place, for the commission to secure reliable data relative to the times of arrival of the various food fish. But for upwards of twenty years, Mr. Vinal N. Edwards, of Woods Hole, has kept a careful record, and from this record Mr. George H. Sherwood has made the following statement. [The fish generally arrive off the shores of Rhode Island several days before their arrival at Woods Hole.]

On the beginning of April, the average temperature of the water is about thirty-seven degrees, and late in the month, when the water has reached a temperature of about forty-six degrees, the scup make their first appearance. At about the same time the menhaden arrive, and the mackerel on several occasions have been taken on May 1st, when the average temperature is only forty-seven.

The times of arrival of the blue-fish have been gradually postponed from year to year, until, in 1899, none were taken in Buzzard's Bay until June 23. In 1878 they arrived as early as the 8th of May, when the water has an average temperature of fifty degrees. From 1880 to 1890, the average time of their arrival was about one week later, when the water has a temperature of fifty-two degrees. From 1890 to 1899, the mean time of their arrival was June 10, when the temperature of the water reaches sixty degrees. Of course it is well-known that, whereas twenty years ago the blue-fish might have been taken by the hundreds it is now captured only in small numbers, or as scattering individuals.

The squeteague have not departed materially from the mean time of their arrival, that is, about May 11, when the water has a temperature of fifty-one degrees. The remarkable increase in the catch of squeteague is in marked contrast to the decrease in the catch of blue-fish.

The following tables are similar to those that have been published heretofore by the Commission. They show a gratifying increase in the number of fish shipped from Newport, although the data by no means represent the actual conditions. Many fish are taken to the New York market in smacks and by private steamer, and the lobsters shipped from Newport are not all taken from our own shores. The sword-fish, one hundred and sixty-two in number, were much more abundant than in previous years.

Shipment of Fish and Lobsters by Regular Lines of Freight Transportation from Newport, for the Years 1898 and 1899.

	1898.	1899.	1898.	1899.	1898.	1899.
	Bbls. Fish		Bbls. Lobsters.		Number. Swordfish.	
January	518	561	11	296	..	..
February	509	276	..	519	..	..
March	112	224	1	362	..	..
April	475	2,004	38	578	..	..
May	11,583	12,971	219	584	..	6
June	8,668	6,945	212	489	..	38
July	3,144	3,869	432	642	14	6
August	3,378	3,237	213	401	7	52
September	2,351	2,106	25	182	1	26
October	2,441	1,575	4	51	..	18
November	648	804	5	15	52	8
December	235	345	13	24	..	8
Total	34,065	34,917	1,163	4,143	74	162

Total of fish and lobsters, 1898 : 35,228 barrels.
Total of fish and lobsters, 1899 : 39,222.

The following is a tabulated statement of the relative quantities of fish shipped by freight from Newport, over the Old Colony ilnes for the past fourteen years :

NARRAGANSETT BAY.

SHOWING THE LOCATION OF FISH TRAPS FOR 1899.

PREPARED BY THE RHODE ISLAND COMMISSION OF INLAND FISHERIES
TO ACCOMPANY REPORT FOR 1899.

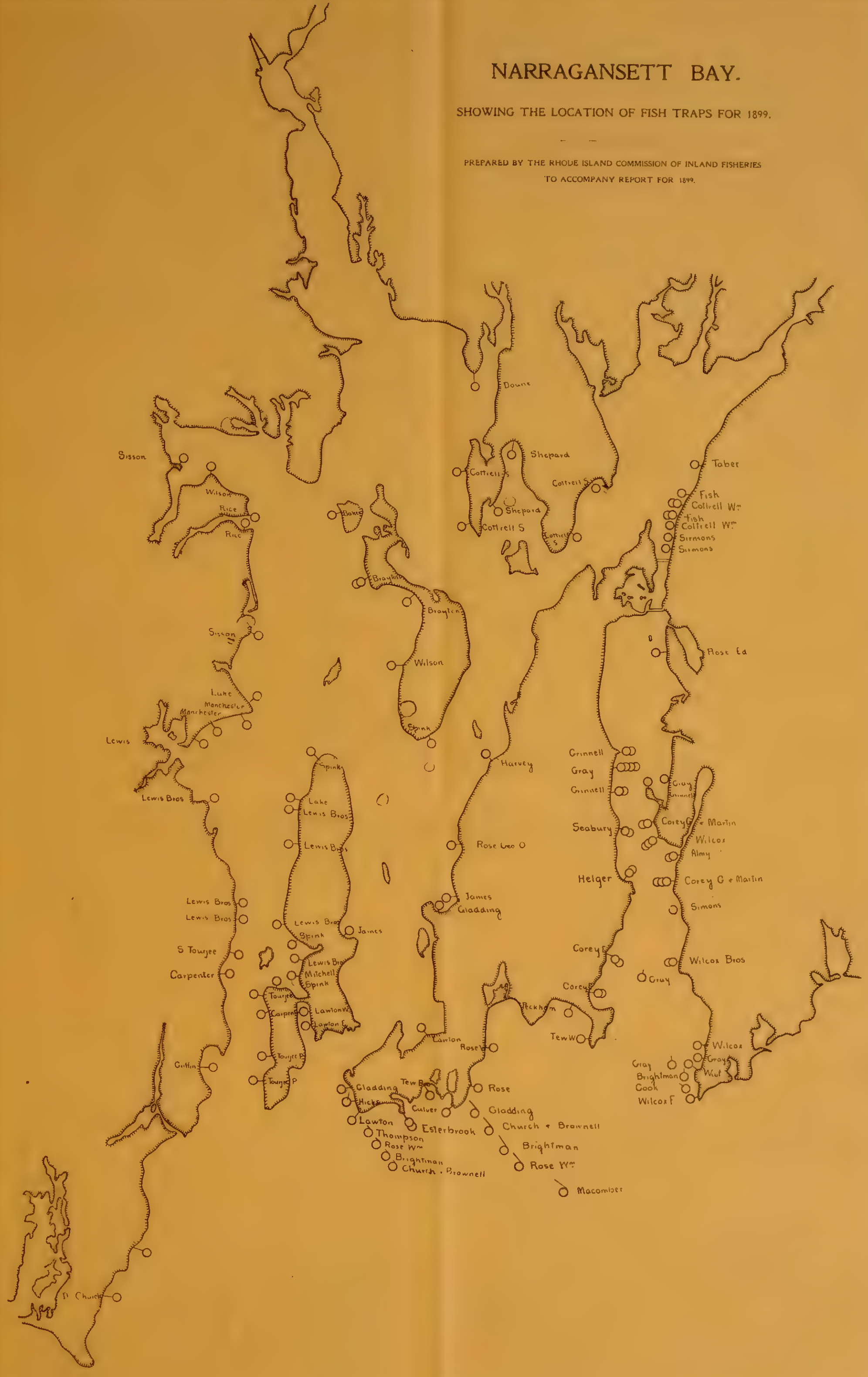

Table of Shipments by Old Colony Lines.

	Fish. Bbls.	Lobsters. Bbls.	Total.
1886			17,414
1887	16,657	834	17,491
1888	15,033	1,161	16,194
1889	19,306	2,047	21,353
1890	8,933	2,650	11,583
1891	18,032	2,204	20,236
1892	26,832	2,123	28,955
1893	24,452	1,399	25,851
1894	17,769	2,392	21,161
1895	24,622	2,119	26,741
1896	20,425	1,728	22,153
1897	20,900	1,959	22,859
1898	34,065	1,163	35,228
1899	35,664	665	36,329

3. A CONTINUATION OF THE OBSERVATIONS ON THE BREEDING PERIOD OF NATIVE MARINE ANIMALS.

The Commission gave its reasons for undertaking this line of work in the report for 1898. It has continued its record during the past year, and will make a final report at some subsequent time.

4. THE LOCATION OF FISH-TRAPS WITHIN THE WATERS OF NARRAGANSETT, AND THE COLLECTION OF STATISTICAL DATA BEARING UPON THEIR OWNERSHIP.

With the publication of the report for 1898, the State first came into possession of definite data respecting the location and ownership of fish-traps. Assisted by the boats of the U. S. Fish Commission, your Commission has again visited all the fish-traps, located them upon its chart, and determined their ownership. We would repeat that the equipment and maintenance of these appliances represent the investment of considerable capital, and the employment of a large number of men. A large proportion of the fish captured are consumed beyond the limits of the State, and the list of cities to which shipments are directly made indicates very clearly the reputation which the State must enjoy as a fisheries centre. It is unnecessary to argue that large sums of money are brought into the State through the activities of those immediately interested in this industry. A list of the principal owners of fish-traps is here given, together with the localities at which the traps are set.

Almy, Frank K. (00)*	Sakonnet River.
Baker, Peter	Patience.
Brayton, R	Prudence.
Brayton, R. (00)	Prudence.
Brightman, Wm. J	Sakonnet Point.
Carpenter Bros	Saunderstown.
Carpenter, Geo	Beaver Head.
Church, Dan	Narragansett Pier.
Cook, C	Sakonnet Point.
Corey, Ed. (00)	Sakonnet River.
Corey, Ed. (00)	Sakonnet River.
Corey, Geo. and Martin (000)	Sakonnet River.
Corey, Geo. and Martin (00)	Sakonnet River.
Cottrell, S	Popasquash.
Cottrell, S	Popasquash.
Cottrell, S	Bristol.
Cottrell, S	Mt. Hope.
Cottrell, Wm	Tiverton.
Cottrell, Wm. (00)	Tiverton.
Culver, Geo	Coggeshall's Ledge.
Doane, S. P	Rumstick.
Easterbrooks, Comer (00)	Price's Neck.
Fish, Clinton	Tiverton.
Fish, Clinton (00)	Tiverton.
Gladding, A. B	Brenton's Point.

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*The signs (00) and (000) indicate double and triple traps.

Gladding, A. B	Coddington Cove.
Gray, Geo. E	Sakonnet River.
Gray, Geo. E. (0000)	Sakonnet River.
Gray, Geo. E	Sakonnet Point.
Gray, Geo. E	Sakonnet Point.
Griffin,———	Watson's Pier.
Grinnell, Philip	Sakonnet River.
Grinnell, Philip (00)	Sakonnet River.
Grinnell, Philip (00)	Sakonnet River.
Grinnell, Philip (00)	Sakonnet River.
Harvey, Charles	West Shore.
Helger Henry (00)	Sakonnet River.
Hicks, O. G	Brenton's Point.
James, Arnold	Coddington Cove.
Lake, Isaac	Conanicut.
Lake, Isaac	Quonset Point.
Lawton, Ed	Mackerel Cove.
Lawton, Wm	Mackerel Cove.
Lawton, Ed	Brenton's Point.
Lawton, Ed	Brenton's Cove.
Lewis Bros	Plum Beach.
Lewis Bros	Plum Beach.
Lewis Bros	Wild Goose Point.
Lewis Bros	Sauga Point.
Lewis Bros	Conanicut.
Lewis Bros	Conanicut.
Lewis Bros	Conanicut.
Lewis Bros	Conanicut.
Manchester, Daniel	Quonset Point.
Mitchel, Gordon	Conanicut.
Northrop Bros	Beaver Tail.
Peckham Bros	Sachuest Cove.
Rice, Herbert	Potowomut.
Rice, Herbert	Potowomut.
Rose, Wm	Conrad's Cove.

Rose, Wm	Coggeshall's Ledge.
Rose, Geo. O	West Shore.
Rose, Ed	Sakonnet River.
Seabury Ben. (00)	Sakonnet River.
Shepard, J	Bristol.
Shepard, J	Popasquash.
Simons, Wm	Sakonnet River.
Spink, J. W	Beaver Tail.
Spink, J. W	Conanicut.
Spink, J. W	Conanicut.
Spink, J. W	Prudence.
Sirmons, John M.	Tiverton.
Sirmons, John M	Tivevton.
Sisson,———	Allen's Harbor.
Sisson,———	Chippanogsett.
Taber,———	Tiverton.
Tew, Eugene and Geo	Cherry Neck.
Tew, Walter	Sachuest Point.
Tourjee, P	Beaver Tail.
Tourjee, P	Beaver Head.
Tourjee, Steven	Saunderstown.
Wait, Ben	Sakonnet Point.
Wilcox, Frank	Sakonnet Point.
Wilcox Bros. (00)	Sakonnet River.
Wilcox Bros. (000)	Sakonnet River.
Wilson, Al	Potowomut Rocks.
Wilson, Al	Prudence.

Sea-Traps.

Brightman, W. J	Off Seal Rock.
Brightman, W. J	Off Coggeshall's Ledge.
Church, J. B., and Brownell, J. M	Off Seal Rock.
Church, J. B., and Brownell, J. M	Off Coggeshall's Ledge.
Cottrell, Geo. F	Off Cormorant Rock.
Gladding, A. B	Off Coggeshall's Ledge.

Macomber, Frank	Off Cormorant Rock.
Rose, Wm. R.	Off Seal Rock.
Thompson, Noah	Off Seal Rock.

5. Observations to Show the Influence, if any, that Trap-Fishing May Have Upon Line-Fishing.

The influence that the trap-fishing in the lower portion of the bay may have upon the abundance of food-fish in the upper portion of the bay has been an oft-disputed question. The heat of argument at any time has been in inverse ratio to the number of fish visiting our shores. The general question of the inexhaustibility of sea products has received special attention during the past year. W. C. McIntosh, director of the Scottish Marine Laboratory at St. Andrews, and for several years member of the Fishery Board, has endeavored to show, in his book "The Resources of the Sea," that there is little danger of over-fishing, that restrictive legislation is unnecessary, and that Nature is amply able to maintain an abundant supply, no matter what demands may be made upon her. Views so entirely at variance with the convictions of those who have made fishing a profession, so radically different from the opinions of those who occupy positions that have enabled them to study the abundance of various commercial fishes from year to year, and views that deliberately set at nought the legislative provisions of the various maritime countries, have naturally been seriously questioned, and the discussions have certainly brought many facts to the surface that otherwise would have remained unknown.

So far as our own interests are concerned, there seems to be little question that certain of our native fishes have been sadly reduced in numbers through neglect and excessive fishing, but the abundance of many forms which annually come in from the open ocean, and visit our shores for the purpose of breeding, appears to remain unaffected. For all that there have been no fewer than 100 traps, set at various places along the shores of the lower portion of the bay, the line-men have had all the scup and squeteague fishing that they could desire. Indeed, scup were never more abundant in Narragansett Bay than during the past season, and the squeteague were never more plentiful. Rod and line fishermen were literally satiated. The young of both these fish have been seen in enormous numbers in the more shallow inlets, and there is every indication that the coming year will be quite as productive as the past.

During the last two days of October and the first six days of November there was a run of mackerel along the shores of Cape Cod, as unexpected as the numbers were unprecedented. Although many traps had been removed, and the mackerel fleet had abandoned work for the season, fully six thousand barrels of mackerel of large size and excellent quality were taken from the shores of Cape Cod Bay, not to mention those that were taken from the southern shores of New England. The sudden appearance of such an enormous number of large fish is evidence that the mackerel has not suffered seriously from the wholesale methods of capture to which it has been subjected, for according to all accounts the fish that were taken were only the scattering individuals along the edge of a veritable migratory wave passing from the north toward the south.

It is certainly worthy of note that while Rhode Island is profiting by her one hundred fish-traps, giving employment to many of her residents, and receving a generous income from her exports, Buzzards Bay, although offering no greater inducement to the hook and line fishermen, is yielding little or nothing because of the closure of the area to the trap-fishermen by legislative enactment.

6. THE CONTINUED EXAMINATION OF THE PHYSICAL AND BIOLOGICAL CONDITIONS OF THE WATERS OF THE BAY, BEGUN IN 1898.

Through the courtesy of the U. S. Fish Commission, we have been enabled to collect additional data of a physical and biological nature, which will be retained by the Commission until ready for publication.

7. Experiments to Test the Feasibility of Clam-Culture.

Mindful of the alarming decrease in the number of clams annually taken from the shores of the State, your Commissioners have begun a series of investigations to test the feasibility of clam-culture. It was the purpose to prepare certain tracts of the shore line, and to plant small clams under varying conditions, to the end that we might know their rate of growth and secure data that might enable us to proceed more intelligently and more effectually the coming season; or, if convinced of the impracticability of clam-culture, to divert our energies in other directions.

Inasmuch as the laws of the State do not provide for the preemption of any portion of the shore for this or similar lines of work, and since the experiments might come to an untimely end at the hand of those who claim a right to all portions of the shore line, your Commission thought it best to conduct the experiments on tracts of land controlled by the United States government, where trespassing could be prevented, and where a general supervision of the grounds could be maintained during the winter months without expense to the State.

Seventy-one plats, each containing one hundred square feet, were selected at four localities, the places chosen being selected because of their extreme physical differences. One had a hard gravelly bottom, covered at high tide by water containing debris and refuse material from various sources. The second locality was partially covered by large rocks more or less imbedded in a hard mud almost like clay. The third point selected for observation was a locality where clams had once abounded, and where a few still remained. The soil was a loose muddy sand of dark color, relatively free from stones and refuse material. None of the clams found on this bed were less than two and a half inches in length, and were of the thick-shelled variety, evidently of slow growth. This bed was the largest upon which we operated, and it was exposed only at exceptionally low tides. The fourth locality was selected because it appeared to be a place where the native clam grew with greater rapidity. There was a free circulation of clear water, and the soil was of varying consistency, ranging from light sand to a deep slimy mud.

In all the above cases, alternate squares, each containing one hundred square feet, were "cultivated," the soil spaded over to the depth of a foot, and all large stones removed. The soil was then raked, and by means of a movable frame divided into small squares measuring one foot along each side.

Seed clams were taken from different localities, some from the warm water of shallow estuaries, others from the cooler water of the coast line, and still others, "paper shells," from protected sandy coves. All the clams, several thousand in number, were carefully measured, sorted into sizes, and registered. In transplanting, care was taken to place the clams not always under the most favorable conditions, and a record was kept of the exact spot in which each clam was placed. In each of the four localities the clams were distributed some according to their source, others according to their size, some were crowded together, and others were given a superabundance of room. Some were driven deep into the mud; others were placed near the surface. Some were placed where they would be always covered by the water, and others were placed near the high-tide mark. At the end of the season, as a further precaution, signs were placed over the beds, prohibiting people from molesting them, and there is, up to the present time, no evidence that the beds have been disturbed. It is now our purpose to leave these beds until the clams have been in their new environment for at least a year, when they will be remeasured, their rate of growth recorded, and we shall then possess some idea as to the feasibility of planting and protecting the young until they are of marketable size.

8. A Preliminary Survey of the Shores of the Bay, for the Purpose of Determining Those Portions Which in the Past Were Productive Clam Beds.

Your Commission has spent considerable time in visiting various portions of the bay, and finding from the older residents those localities which have been known to be productive clam beds. These data are on file with the Commission, and when we have added to them the areas now naturally seeded by the remarkable set of 1899, it is our purpose to issue a chart which will show the total area which might be inhabited by the clam.

9. An Investigation of the Life-Habits of the Clam, Its Breeding Period, Its Food, Its Rate of Growth, Its Natural Enemies, and Experiments to Test the Feasibility of Artificial Propagation.

This work was intrusted to Dr. A. D. Mead, who has prepared the following report:

OBSERVATIONS ON THE SOFT-SHELL CLAM.

BY A. D. MEAD, BROWN UNIVERSITY.

The following "comparative statement of the yield of clams in the New England States during a series of years" shows of what importance the clam industry has been in our State. It shows also a very considerable decrease in the yield of clams since 1880, and at the same time a marked increase in the price per bushel.

The statistics were arranged by Dr. Hugh M. Smith, of the U. S. Fish Commission, and with the exception of one item, were published in the report of the Commissioner for 1894. Through the kindness of Dr. Smith the data for Rhode Island for 1898 are added.

Maine.

	Bushels.	Value.
1880	318,383	$101,808
1887	608,780	228,490
1888	600,675	227,665
1889	595,105	200,761
1892	416,806	157,431

New Hampshire.

	Bushels.	Value.
1880	17,960	$8,980
1887	280	140
1888	300	150
1889	300	150
1892	1,050	975

Massachusetts.

	Bushels.	Value.
1880	158,626	$76,195
1887	230,659	121,202
1888	243,777	127,838
1889	240,831	137,711
1892	191,923	133,529

Rhode Island.

1880	53,960	$48,564
1887	25,825	25,030
1888	30,825	30,030
1889	33,375	32,475
1892	33,950	45,222
1898	15,015	20,569

Connecticut.

1880	75,000	$38,000
1887	26,735	25,370
1888	26,575	24,270
1889	26,360	24,900
1892	23,780	25,320

Total.

1880	623,929	$273,547
1887	892,279	400,252
1888	902,152	409,953
1889	895,961	395,997
1892	667,509	362,477

The Extent of Shore in Narragansett Bay Available for Rearing Clams.

From its geographical peculiarities, our State is particularly well adapted for clam culture; the Bay has a long shore line for so small a body of water, on account of the many peninsulas, estuaries, and islands, and nearly all the shore is protected from the heavy seas. In order to ascertain how much of the shore in this State is suitable for the growth of clams, a preliminary survey of the bay was made.

Through the courtesy of the United States Fish Commission, the steam launch Blue Wing was detailed to aid in collecting this information, together with data concerning the location of fish-traps, and the density and temperature of the water in various parts of the Bay. A considerable extent of the shore was examined directly, but for most of the information we are indebted to numerous fishermen and other residents, who from long experience have particular knowledge of certain localities.

There are in the aggregate more than fifty miles of shore which is considered good clam ground, and this is not limited to any portion of the Bay, but is found in all parts, wherever in fact there is soil enough for the clams to bury themselves. It is not by any means necessary that the ground should be soft, for hard clay and exceedingly stony ground often yield a good crop of clams. In many localities, also, no clams occur above the mean low-water mark, while they are comparatively abundant lower down and can be dug in the ordinary manner when the tide is uncommonly low. Nowhere, however, are the clams abundant to-day, and it is the common testimony from all parts of the Bay that, although they were exceedingly abundant from ten to twenty-five years ago, they are now comparatively scarce. The shores are, at present, almost depleted, and the difficult process of "churning" them in several feet of water is often resorted to by those who make a business of supplying clams to the market.

The set of clams was exceptionally large last summer (1899) in various parts of the Bay, for example about Green's Island (Conimicut), at Wickford, in the Kickemuit river, and on Oakland Beach. It will be interesting to observe how long the clams will remain abundant in these localities.

Since the above was written, on February 5 and 6, (1900), there were a great many bushels of extremly large clams in the markets.

They were taken from the flats in various parts of the bay at Wickford, the Kickemuit river, and other localities, when the tide was phenomenally low. One of the largest specimens, taken from Wickford, measured 5¾ inches in length and weighed 15 ounces; and a bushel taken at random from the market contained only 119 clams.

Egg-Laying, and Habits of the Very Young Clams.

The eggs of the clam, like those of the oyster, are exceedingly minute. Like the latter, also, they are extruded into the water where they are fertilized, and where they develop into free-swimming larvæ. The exact limits of the egg-laying period of the clam have not been determined, but it probably extends through the months of May and June, as Dr. Kellogg conjectured in the last Report.

On the eighth and on the twelfth of May the clams examined at the Kickemuit river were full of sexual products, which appeared under the microscope to be nearly ripe. On May 22 I succeeded in fertilizing some of the eggs artificially by dissecting them out into a dish of sea-water and adding the sperm taken from the male clam in the same way. The early stages of development were regular and apparently normal, but, unfortunately, I could not remain at the house-boat to care for the eggs, and they died. The experiment proved, at least, that the clams were ready to breed toward the last of May, and that it is possible to fertilize the eggs artificially.

On May 29 a silk net was obtained which was fine-meshed enough to hold many of the free-swimming young of the clam, and from this date until the second week of July these minute clams were taken at Wickford almost every day by dragging the net along the surface of the water.

The specimens caught in this way are hardly visible to the unaided eye. By the aid of the microscope they are seen to have two shells hinged together, and in this respect they resemble the adult clam. In order to procure them for examination the skimming-net is shaken out in a dish of water. The clams may then be separated from the myriads of other small organisms by gently tapping the dish, when they will stop swimming, close their shells, and fall to the bottom. They are then easily picked up with a pipette, and transferred in a drop of water to a watch crystal under the microscope. When first caught they vary considerably in size, some being four times the diameter of others, as shown in the figure (Fig. 1). As one watches these specimens under the microscope he will frequently see one of them open its shell, thrust out and expand a circular swimming-organ and go whirling about in the water for a while; then as suddenly, this organ, the velum, is drawn in, the shells close over it, and the clam falls to the bottom and remains quiet. Figure 4 is a free-hand sketch of one of these swimming clams (caught on May 29) with the swimming-organ expanded. Around the margin of the latter are the rapidly moving cilia, which create a current of water in the direction indicated by the arrows. This specimen had struck a snag, and was held by it while the sketch was made; smaller organisms and particles of dirt were swiftly swept backwards, meanwhile, by the energetic strokes of the cilia. In the midst of the organ is a long, slowly moving flagellum or lash, which may, perhaps, serve as a feeler.

Inasmuch as there are no published figures of the clam at this stage, it was not possible upon the mere examination of these creatures to say definitely that they were the young of the soft-shelled clam. It was presumed that they were, however, not only from their appearance but from the fact that the adult clams a week or two before were ready to lay, and, further, from the fact that by the last of June the young set of clams is well started. (See Kellogg's Report, 1898.) The absolute proof that they were clams was forthcoming, however, for a number of specimens were isolated and kept alive in dishes for several weeks. During the first week or two they grew considerably, lost their swimming-organ, and took on unmistakable characters of the soft-shelled clam. Figure 2 is from a camera drawing of one of these living clams two weeks after it was caught, *i. e.*, on June 14. It is drawn to the same scale of magnification as those in figure 1. The shape of the shell has been greatly changed, and the clam is more than twice the length, and many times the bulk, of even the largest specimen when first caught. The siphon (snout), gills, liver, stomach, and heart, and the relatively large foot have been developed, the internal organs showing plainly through the transparent shell. Figure 3 represents the same individual, drawn with the camera, to the same scale, ten days later, on June 24. The body is now still further elongated, the gill-plates are considerably more numerous, the foot is, perhaps, somewhat larger in proportion, and a peculiar sense organ, the so-called ear, is plainly visible within the substance of the foot. The lines of growth, which can be easily made out upon the shells themselves, show the changes in shape which have taken place during the process of growth. Although the rate of growth in this specimen is seen to have been quite rapid—from the size of one of those in Fig. 1 to that in Fig. 3 in less than three weeks—it was doubtless much less rapid than it would have been under natural conditions; for this specimen was kept in a dish, the water being changed only a few times, so that the supply of food, which consists of microscopic organisms, was very meagre as compared with that in the tide-water.

Among the clams caught in the skim-net there were usually many in which the foot and siphons were already developed. Such specimens, when watched under the microscope, would crawl about by means of the foot instead of swimming; yet they must have been able to swim, since they were taken near the surface of the water. I am not certain whether the swimming-organ was still capable of being used, or whether they swim with the foot. The latter method I would have thought almost impossible had I not seen it in use by razor clams which were many times larger. On the evening of July 20 a large number of razor clams, some of the latter measuring seven millimetres (more than a quarter of an inch), were taken in the tow-net. The shells were well-formed and hard, but the animal swam rapidly about by means of a curious kicking stroke of the very long foot. They were never taken in the tow except on this occasion, a rainy evening when a strong wind was blowing.

Whatever method of swimming the young clams may finally use, it is certain that they swim freely in the water until the foot and siphon are developed and they are thus equipped for crawling about over the sea-weed, stones, sand, and other objects they happen to strike upon.

A specimen whose swimming-days were past is represented in Fig. 5. The double nature of the siphon is shown at this stage, the incurrent and excurrent portions being almost separate from each other. The dotted lines represent the foot as it appears when the shell is closed, and the foot thrust out is represented by the solid lines. It is impossible to obtain more than a hasty camera sketch of the outstretched foot because its movement is so quick. The foot reaches out sometimes considerably further than the picture indicates, takes hold of the bottom of the dish, and with a quick jerk the shell is pulled up to it, the whole operation not occupying more than a second or two. By this rather clumsy method of travelling the clam is able to make considerable progress.

A few days after the clams are caught at the surface they are found to have attached themselves to the bottom of the dish or to any object which happens to be near them. Kellogg found last year these very small specimens attached to sea-weeds and other objects and carefully studied their habits from this period of life, when they are less than one-fiftieth of an inch in length, until they are finally settled in the ground. He showed that they attach themselves to objects by spinning byssus threads as the mussels do, but that they can at pleasure release themselves from the attachments, crawl about and attach themselves again. The ability to attach itself remains until the clam is upwards of one-half an inch in length, and by this time most of the clams which survive have buried themselves in the ground. Fig. 24 is a life-size photograph of a small clump of clams anchored by byssus threads to a mussel-shell and to stones. As Kellegg pointed out, this capacity is of greatest advantage to the clams; for those which happen to set upon sea-weed, stakes, stones, etc., are able, with some degree of safety, to wander about until they find a suitable place in which to burrow, and those which are not satisfied with the ground where they first burrow can come out and go to a new place, as they were actually seen to do. Of the greatest utility, however, is the habit of anchoring themselves in the burrow so that they cannot be so easily washed out.

While the rock-weed and other algæ are of great service to the clams in furnishing them with a convenient temporary lodgment where they will not be smothered by the silt when they are very small, it is true also the clams set in great quantities and grow in some sandy beaches where there is no sea-weed.

Some General Features of the Clam Set.

By the first week in July, 1899, a great many clams had already found their way into the sand. At this time they were so small that they escaped general notice, ranging from a size at which they were hardly visible to 9 millimetres in length. (See Fig. 6). By the third week in July a great majority had burrowed, and then there were probably more of this year's clams in the sand than at any other time during the year, for during the next few months they were destroyed in enormous quantities. Although the free-swimming young were, in their season, abundant at all times and at places in the water of the harbor (Wickford), the set of clams which was found buried in the sand was very unevenly distributed. The sandy shore in some places was literally filled with them from below low-water mark to about the half-tide mark. Here it would be impossible to pick up a handful of sand without taking up with it several clams. Within a few rods of these specially fertile areas however, in the same sort of soil, only a comparatively few clams were to be found—not one-thousandth as many as in the former places.

It was very apparent in these cases that the abundance or scarcity of the set was not due to the quality of the soil nor to the quantity of old clams in the vicinity, nor yet to the absence of enemies, but was due probably to the position of the shore with reference to the tide currents. Some of the areas where the set was exceedingly thick were, moreover, far from being the best for adult clams, and the reason is not far to seek. In one case a certain point of shore was set in the middle of July as thickly as the clams could burrow, but by the ninth of August hardly a young clam could be found. They were apparently washed out or were covered with shifting sand. In another locality, about 40 rods from the last, the set was discovered on July 5 and was also very thick. These clams continued to be abundant throughout the summer and autumn, and, though meanwhile they were somewhat thinned out, were yet very numerous on December 4. The thinning out began in July, and from this time until September there was always a wind-row two or three feet wide of small clam-shells along this portion of the shore. Very often among these shells one would find live clams and preying upon them a whole army of star-fishes, crabs of various species, and mummichogs. Undoubtedly the crabs, especially the blue crabs "paddlers," and some other animals dig up or uncover the young clams and scatter them about where they fall prey to many enemies; but I think one important factor in their wholesale destruction lies in the fact that they set much thicker than they can grow and a great many are crowded out, or, at least, if they are once brought to the surface of the ground, cannot burrow again. When the clams are not more than one-fourth of an inch long—early in July—they were near together, but when by the last of July they had become several times longer and many times the bulk, they actually touched each other; for at this period they all buried themselves to about the same depth. As one walked over the ground, or tapped it, the whole surface for a yard or two would move perceptibly as the clams contracted.

A more definite notion of the abundance of the clams in the locality mentioned above will be gained from the following: On August 9, after they had become somewhat thinned, a square yard on the shore was staked out and the clams dug from it as carefully as possible. These were carefully picked over and all stones and shells sorted out. There were then ten pints of clams. Two pints were counted, the first yielding 1,200 clams, the second 1,300. The average of the two pints was therefore 1,250, and the estimate for the clams (ten pints) taken from one square yard is 12,500. In addition to these a considerable number, perhaps a thousand, were lost, being scattered by the tide.

The Rate of Growth.

The rate of growth of the clam, like that of the star-fish, is, under favorable circumstances, more rapid than is usually supposed. It was shown in the last Report that the rate of growth in the star-fish varied greatly according to the amount of food, and that of two healthy star-fishes of the same age one might be more than one hundred times the bulk of the other. The same variation, resulting from differences in food supply, is seen in the clams, though perhaps the difference is not so great.

The growth of the clams, which set thick at Wickford, on Cornelius Island, was followed during the summer, and formed the basis for comparing the growth in other localities. The following figures, photographed life-size, will show the rate of growth of the clams in this locality. Figure 6 represents specimens taken July 7; the larger of these are probably about five or six weeks old, judging from the data with regard to setting already mentioned. Any possible doubt that they are the set of this summer is removed by the fact that a large number of specimens set on the house-boat, which was put into the water on the first of May, were about the same size.

The succeeding figures, from 7 to 14 inclusive, are all life-size photographs of clams taken from the same locality as those in Fig. 6, at various times during the summer. The specimens photographed were selected as representing the average size on each date, together with some of the larger and smaller sizes, placed in the bottom and top row, respectively.

The Rate of Growth Under Specia Conditions.—On the sixth of July about a pint of clams, taken from the point already referred to, were placed in a box of sand in the house-boat, and about one-half pint more were added on July 9. The clams were not covered with the sand, but were simply scattered over the surface, many of them sticking together in clumps. In about five minutes they had all burrowed out of sight. The sand box was sunk about 18 inches below the surface of the water, and, not being affected by the rise and fall of the tide, was kept submerged at this depth for a month. During the following month, it was occasionally exposed at low tide when the house-boat was ashore.

The growth of these specimens was compared from time to time with that of the clams in the original locality on the shore, and with the somewhat surprising result that the clams at the house-boat grew much faster than those on the shore, whence the former were originally taken. It is clear, therefore, that it is not necessary for the rapid growth of the young clams that they be in a locality which is exposed at low tide—on the contrary they grow faster when they are submerged all the time. This difference in the growth of the clams on the shore and in the house-boat is illustrated by the photographs of samples taken from two localities at various times. Compare Fig. 9 with Fig. 14; also Figs. 10 and 15; Fig. 11 and Fig. 17; Fig. 12 and Fig. 18.

It might be asked whether the more rapid growth at the house-boat was not due to the more favorable position of the latter in the tide currents. This may be true in some measure, but yet the point of shore in question was washed by a strong current also. The house-boat, moreover, was moored within a few rods of the point, so that the character of the food is about the same. Some other observations confirmed the conclusion that clams grow faster when they are continuously submerged. On September 7, on another part of the shore, the young clams were examined at various levels, from below mean low-water mark to half tide, and the larger growth of the former was noticeable. This is illustrated by samples which were taken at very low tide, and at about half-tide (Figs. 21 and 22).

The following experiment, made to ascertain the rate of growth of individual clams transplanted to another locality on the shore, shows, also, that the growth is greater near the low-water mark. On the 22d of July a number of young clams of average size, taken from the point on Cornelius Island, were carefully measured, and planted in the land tiles. The tiles were set perpendicularly into the ground, and filled with sand taken from *above* tide mark, in order that no clams might be accidentally put into them, and were arranged in a row, from extreme low-water mark to high-water mark, at intervals of about two feet. Each clam was carefully measured and placed in a tile by itself (in some cases two specimens were put into the same tile). On September 18 some of these were taken out and measured again, the rest being left undisturbed. The measurements are of the long diameter of the shell, and are given in millimeters. The accompanying diagram shows the relative position of the tiles which contained the specimens measured on September 18. No. 1 is at extreme low tide, and No. 8 some what below half-tide mark.

Number.	July 22.	September 18.	Growth in 2 Months.
(8)	.........13mm	28mm	15mm
(7)	.........12 "	36 "	24 "
(6)	.........14 "	40 "	26 "
(5)	....		
(4)	.........11 "	44 "	33 "
(3)	.........13 "	46 "	33 "
(2)	.........15 "	48 "	33 "
(1)	.........13 "	gone.	

Reference to this table shows at once that the clams grow more slowly as we go up the shore from low-water mark. Compare for example Nos. 3 and 8, which at the time of planting were of the same size, but two months afterwards differ 15 millimeters, or more than one-half an inch.

It is not certain, of course, that the difference of rate of growth at different levels is always as marked as in this case, and more experiments must be tried to ascertain the relative growth accurately. This experiment, so far as it goes, substantiates the conclusion already stated that clams grow faster when they are under water the greater part of the time. The reason for this is not very far to seek. The food of the clams consists of microscopic organisms contained in the water, which is taken in through one siphon and expelled through the other. The clams can feed, therefore, only when covered by water, and those which are located at some distance above the low-water mark are shut off from the food supply during a considerable portion of each day.*

This record of growth of the clams in the tiles is interesting also because it demonstrates that clams may grow during their first summer nearly to marketable size. The specimen in tile No. 2 was not among the very largest of the set on the point at the time it was transplanted, and not larger than some of those which had set in the floating house-boat; so that there is no question about it being of this year's production. On July 22 it measured 15 millimeters—the size of the specimen in Fig. 20. On September 18, in less than two months, it had more than trebled its length and had burrowed about six inches into the sand. The specimen was preserved on September 18 and is photographed natural size in Fig. 20 by the side of a clam of fifteen millimeters in length. The growth of the two adjacent specimens in the tiles Nos. 3 and

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*Since the rapidity of growth of the clams depends directly upon the supply of microscopic organisms in the water, it is to be expected that a considerably greater growth will be found in some portions of the Bay than in others. I have not had an opportunity to investigate this problem carefully, but through the kindness of Mr. A. W. Bourne some samples of this year's clams were obtained on December 5 which were much larger than those taken at the same time at Wickford. The water in the former locality is extremely rich in microscopic organsims, shown both in the skimmings taken with a tow-net and by the remarkable growth of animals other than clams which depend upon these organisms for food.

4 indicates that the record for the specimen photographed is not exceptional or accidental.

Another experiment made to ascertain the rate of growth of individual clams was tried at the house-boat. On July 19 several specimens were carefully measured and placed in small flower-pots which were filled with sand. These were kept continuously under water, and the clams measured again on September 10. The measurements on the two dates, as given below, show that the clams had grown during seven and a half weeks to two or three times their original length.

Record of Growth of Clams in Pots at House-Boat.

Number.	July 19.	September 10.
(1)	11–11 (2 specimens).	26–23
(2)	9.2	22
(3)	7.5	—
(4)	8.1	27
(5)	12.5	28
(6)	10.9	30
(7)	11.1	25
(8)	8.9	30
(9)	10.5	22 (shell only).
(10)	11.5	20 (shell only).
(11)	11.1	27
(12)	9.0	26

The following will give an idea of the relative increase in bulk of the clams at the house-boat as compared with those on the shore. On August 9 the clams on the point of shore to which we have several times referred were measured by the pint and counted. The average number to the pint was about 1,200. The clams which were taken from the same locality on July 7 and 9, and which had been kept in a box of sand at the house-boat since that date, now measured about 400 to the pint. The clams at the house-boat, therefore, appeared to have so far outstripped those on the shore that in one month they became about three times the bulk of the latter. There is one possible fact, however, which may make this result less trustworthy than the data derived from the growth of marked individuals or from that of the largest specimens in each locality, viz.: the clams which were placed in the house-boat were gathered with a sieve, which, though its meshes were small (ordinary flour-sieve), may have allowed many of the smaller clams to go through; so that the average size of those planted was perhaps less than the average size of those remaining on the shore.

The actual increase in bulk of a certain quantity of clams during ten weeks in the summer is given in the following measurement of the clams reared in the house-boat. The box of sand in which a pint and a half of small clams was planted as evenly as possible, on July 6–9, was divided in the middle by a partition. The clams soon became so crowded that many were probably pushed out; at any rate there was a considerable number of empty shells over the surface of the sand. Notwithstanding this loss, four and a half quarts were taken from one-half of the box on September 18, the other half being left undisturbed. From about three-fourths of a pint, therefore, we had a yield of over four quarts of clams in about ten weeks. We ought also to mention that one pint was taken from the box on August 5, and smaller quantities on several other occasions.

Size and Age at Sexual Maturity.

It is usually maintained that the clam reaches sexual maturity during the third year of its life,* but I am inclined to believe that this does not do justice to the animal in question, and that the clam, like the star-fish, not only grows faster, but arrives at sexual maturity much sooner than is usually supposed. My reasons are as follows:—

1. I found at the beginning of the breeding-season a ripe male

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* See Bulletin 51, R. I. College of Agriculture and Mechanic Arts, December, 1898.

clam of 30 millimeters in length, and a ripe female of 50 millimeters. As we have already stated, many clams, undoubtedly of this year's growth, were more than 30 millimeters long, and some nearly 50 millimeters, before the end of September.

2. In the autumn the sexual glands of this season's clams were considerably developed, although the breeding-season does not occur until spring.

Therefore, while I cannot make it as a positive statement, not having yet followed the development of the sexual glands throughout the year, I would venture the conjecture that many of the clams of last summer's set (1899) will breed next spring (1900).

Summary of Preceding Chapters, and Bearing of These Results on the Problem of Clam Culture in Narragansett Bay.

(1) From the point of view of clam culture, and the practicability and feasibility of re-instating an almost defunct industry, the observations recorded in the preceding pages open up a very encouraging prospect.

(2) The preliminary survey indicates that there are more than fifty miles of Rhode Island shore in the Bay alone which are more or less available for the rearing of clams.

(3) The range and the adaptability of the clam is great. It will thrive in various kinds of soil; in sand, mud, clay, and among stones; from near high-water to considerably below low water; from brackish ponds to the densely salt water of the outside shore and Seaconnet river.

(4) It is the general testimony that the clams have been decreasing in quantity gradually during the last twenty years, and it is an undisputed fact that they are now comparatively scarce. The disappearance has been nearly uniform in all parts of the Rhode Island shore of the Bay; in localities protected from the wash of the steamers and not contaminated by the waste of towns, as well as in localities less fortunately situated. It is still, in certain localities, comparatively abundant below the low-tide mark,

where it cannot be taken by the ordinary method of digging, but only by the more elaborate and unusual method of churning. In Cole's river, where, under Massachusetts laws the clams are better protected, they are much more abundant than in the neighboring Rhode Island estuary, Kickemuit river, though both are similarly situated and the latter has been proved by its past history to be a locality as favorable as the other. These facts and others indicate clearly that the decrease in the clams of the State is due mainly to the unlimited and promiscuous digging and not to changed natural conditions.

(5) That frequent digging up of the ground is necessary, or that it is even a positive benefit to the clams, by rendering the ground soft, is probably a fallacy. The fact that often the finest specimens are found in hard, stony ground, or in hard clay flats, which are only occasionally exposed to the clam-digger at an unusually low tide, and the observations made during the summer upon the growth of unmolested specimens, indicate that they grow well, at any rate, if left undisturbed. The habits of the animal, in obtaining food, point to the same conclusion. The food is obtained from the water which is taken in through the siphon, and not from the soil in which the clam lies. So long as it is well located, therefore, and in communication with the water it is distinctly not to its advantage to be disturbed, particularly at the risk of being buried deep under the mud or left on the surface, a prey to crabs, mummichogs, star-fish, and other enemies. Clams less than one-half an inch long will burrow very rapidly when they are exposed on the surface of the mud (if covered by water), but those upwards of three-fourths of an inch will often lie for a long time without even trying to burrow, and then are not very efficient in getting into the mud. This method of "cultivation," although undoubtedly excellent for apple trees, is not, however, equally good for clams.

(6) The breeding-season of the clam is at its height in June. The exact limits of the period have not been ascertained. The eggs are extruded in great numbers into the sea-water where they

are fertilized and in a short time develop into very minute free-swimming forms with little resemblance to the adults. In this condition they live an active life and are carried hither and thither by the tides for several days at least before they settle down to the bottom or attach themselves to some object like a stone or piece of sea-weed. The obvious result of this method of reproduction is that the young clams do not remain where the eggs are laid but are very widely distributed by the tides. This fact readily explains the sudden appearance of a large set of clams in a locality where the adults are scarce. It is not at all unlikely, moreover, that the clams below tide-mark, and out of reach of their human enemy, produce a large proportion of the clams which set on the shore. (See foot-note, p. 32.)

(7) In the manner of setting, and in the peculiar characteristics of the young clams after they have set, there are two facts which will prove of the greatest service in clam culture. 1. The clam set is not evenly distributed even in regions of the Bay where the water is full of the free-swimming young, but in some localities the set is extremely thick while in neighboring localities, a few rods distant, only a small number may be found. 2. The young clams, from one-fourth to one-half an inch long, have a remarkable capacity for burrowing, a capacity which is greatly diminished as the animal grows larger. At the proper season, therefore, and in the localities where the set is thick, the clams can easily be collected in immense numbers by means of a sieve; and fortunately the time when they can be collected with the least difficulty happens to be the very best time for transplanting. By far the best time for collecting and transplanting is from the first week in July to the first or second week in August. It is hundreds of times easier to collect them at this season by means of a sieve than at other times of the year with a clam-hoe. There is perhaps even a greater advantage in transplanting at this time, from the fact that the clams can now be sowed broadcast like grain and will soon burrow into the sand; whereas, larger specimens from one inch upwards must necessarily be planted and carefully covered

or a great loss will result. An additional fact in favor of transplanting at this time is that in some localities there are very great quantities of young clams set early in July which, if not taken up and transplanted, are destroyed by shifting sand or from some other cause. In other localities the clams are set too thick to grow to the best advantage, and they would actually be benefited by being thinned out.

(8) It seems almost certain that the explanation of the abundant set in a limited area, and the meagre set in the neighboring localities, is to be sought in the position of the shore with reference to the tides. When this explanation has been worked out in detail it may be possible artificially to construct and place apparatus to collect the set in equally large quantities.

(9) The experiments of transplanting have demonstrated that under favorable conditions the rate of growth is more rapid than is usually supposed, some of this year's set having reached a length of nearly two inches by the middle of September. The experiments demonstrate also the fact that there are great differences in the rate of growth according to the food supply which is obtained from the water, and that the most rapid growth may be expected of clams which are under water most of the time.

(10) The size and age at which the clams reach sexual maturity has not been definitely ascertained, but there are facts which indicate strongly that they breed during the first year of their life. It has elsewhere been stated that they do not breed until the third year. The question is important, of course, in view of any attempt at clam culture on a large scale or at restocking the shores.

EXPLANATION OF FIGURES.

1. Sketches, drawn with camera lucida, of young, free-swimming clams, showing shape and variation in size.

2. Camera drawing made on June 14 of a clam caught in the skim-net at the surface of the water on May 29, and kept isola-

ted in a dish of water. Seen from the left side: f, foot retracted; l, liver; h, heart; g, gills; s, siphon or "snout." Arrows indicate incurrent and excurrent openings.

3. The same individual as Fig. 2, drawn to the same scale of magnification, ten days later, viz.: on June 24; e, sense organ (ear?). Other letters the same as Fig. 2.

4. Freehand sketch of clam larva seen through the microscope with swimming-organ (velum) expanded. Around the edge of the velum is the fringe of minute lashes (cilia) whose movements propel the animal. The arrow shows the direction of the current of water created by the rapid stroke of the cilia. The direction of the current is easily ascertained by observing the movement of the small particles contained in the water.

5. Sketch of a clam just set, as seen under the microscope. The large foot and the siphon are shown distended. The dotted line indicates the position of the foot when retracted within the shell. The incurrent and excurrent tubes of the siphon are, at this stage, nearly separate.

6. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on July 7, 1899. The largest specimens are, probably, about six weeks old. Photograph life-size.

7. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on July 14, 1899. The largest specimens are, probably, about seven weeks old. Photograph life-size.

8. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on July 21, 1899. The largest specimens are, probably, about eight weeks old. Photograph life-size.

9. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wick-

ford, R. I., on August 4, 1899. The largest specimens are, probably, about ten weeks old. Photograph life-size.

10. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on August 29, 1899. The largest specimens are, probably, about thirteen weeks old. Photograph life-size.

11. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on September 7, 1899. The largest specimens are, probably, about fourteen weeks old. Photograph life-size.

12. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on September 30, 1899. The largest specimens are, probably, about four months old. Photograph life-size.

13. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on December 4, 1899. The largest specimens are, probably, about six months old. Photograph life-size.

14. Specimens selected to represent the average size of the clams in a marked area on the shore of Cornelius Island, Wickford, R. I., on December 4, 1899. The largest specimens are, probably, about six months old. Photograph life-size.

15. Specimens selected to represent the average size of clams taken on July 7, 1899, from a marked area on Cornelius Island, Wickford, R. I., and reared in a sand-box at the house-boat until August 8. These specimens are, probably, about ten and a half weeks old. Compare with those remaining on the shore until August 4. Photograph life-size.

16. Specimens selected to represent the average size of clams taken on July 7, 1899, from a marked area on Cornelius Island, Wickford, R. I., and reared in a sand-box at the house-boat until August 29. These specimens are, probably, about thirteen weeks

old. Compare with those remaining on the shore until August 29. Photograph life-size.

17. Specimens selected to represent the average size of clams taken on July 7, 1899, from a marked area on Cornelius Island, Wickford, R. I., and reared in a sand-box at the house-boat until September 8. These specimens are, probably, about fourteen weeks old. Compare with those remaining on the shore until September 7. Photograph life-size.

18. Specimens selected to represent the average size of clams taken on July 7, 1899, from a marked area on Cornelius Island, Wickford, R. I., and reared in a sand-box at the house-boat until Septemper 19. These specimens are, probably, about sixteen weeks old. Compare with those remaining on the shore until September 30. Photograph life-size.

19. The large specimen was taken on September 18 from a land-tile set in the mud on the shore (Wickford), at low-water mark. It was placed in the land-tile on July 22, when it was the size of the smaller specimen. The difference in size represents two months' growth. Photograph life-size.

20. These specimens represent the average size of the larger of the clams at low-water mark in a certain locality on the shore at Wickford on September 7. (Compare with those from the same locality at *half-tide* mark.) Photograph life-size.

21. These specimens represent the average size of the larger clams at half-tide mark in a certain locality at Wickford on September 7. (Compare with those from the same locality at *low-water* mark.)

22. These specimens were found among the barnacles clinging to the outside of the house-boat on September 7. They have never been covered with sand or soil of any kind, and are stubby and thick-shelled. Photograph life-size.

23. These specimens were taken on September 7, from the side of the sand-box in the house-boat, and show how the clams of considerable size may remain anchored to various objects, or

to each other, so as to form clumps, like mussels. Photograph life-size.

24. These specimens represent the average (smaller) size of clams taken from the shore in the Kickemuit River on December 4. They are about six months old. Photograph life-size.

25. These specimens represent the average (larger) size of clams taken from the shore in the Kickemuit River on December 4. They are about six months old. Photograph life-size. Compare with those taken at Wickford, on shore, at the same date.

10. CONTINUED WORK ON THE OFF-SHORE FISHERIES.

In the last report attention was called to the existence of valuable fishing-grounds lying but a short distance from our coast, and inhabited by apparently large numbers of valuable food-fish. At that time the trawls had been set in thirteen different localities between the meridian of 69° and 71° of W. longitude, between parallels of 40° and 40° 20′ N. latitude, and in water ranging from 70 to 80 fathoms in depth. Although this work was carried on by the U. S. government, the fact that the tile-fish bank lies immediately to the south of Rhode Island renders its exploration of especial interest to the fishermen of the State. During the past summer the Grampus made three excursions to the Gulf Stream for the purpose of determining the northern and western limits of the area inhabited by the fish. Three of your commissioners accompanied the vessel on one of these expeditions. As a result of the work of 1899 the western limit of the "bank" was carried some miles to the westward of the meridian of 72°, south to the parallel of 39° 47′, and the fish were followed into shallow water of only 55 fathoms depth. At our very doors is this wealth of fish which rival the halibut in quality.

11. EFFORTS AT LOBSTER-CULTURE.

The predictions that have been so often made in regard to the disastrous results that must follow the unrestricted capture of immature lobsters and the destruction of egg-bearing females are being realized. Means more efficient for the annihilation of the lobster could scarcely be devised than those now employed. It is legal to capture and kill at all times of the year, and the animals are destroyed illegally without respect to size or sex. The spawn of the few egg-bearing lobsters which approach our shores from the deeper water is combed from the appendages, destroyed, and the sterile mother carried to the market.

With an important industry thus threatened with early extinction, the Commission has adopted the only means within its power to ward off the calamity. It has continued the experiments begun in 1898, which were described in its twenty-ninth report.

Early in May a member of your commission, and two assistants, established themselves at Woods Hole, receiving an unlimited number of lobster-fry from the government hatchery. It has been suggested often that if the fry could be placed in a small bay of salt water and protected from their enemies, they would doubtless flourish and come to maturity. Through the kindness of Camillus G. Kidder, Esq., a small enclosure was placed at our disposal, the bottom was carefully cleaned, a dike was built to make the enclosure more secure, and after repeated seinings we considered the enclosure freed of animals that might prey upon the fry. After testing the temperature and specific gravity of the water, several thousand lobster-fry were liberated, but on the following day not a single one could be found. The young seemed to perceive the slightest movement of the water, and following the current, probably passed out through the minute crevices in the embankment. The further possibility of their escaping in this manner was then prevented by placing lengths of scrim across the openings; but the fry would attach themselves to the cloth, at the ebb of the tide, and, there entangled, would become exposed to the sun and perish. Repeated experiments convinced us that until we could find a larger natural enclosure, further work in this direction would be profitless.

The importance of suitable and sufficient food was emphasized in the last report, and if the young are not provided with such they perish soon after they have escaped from the egg. We have succeeded in finding an excellent food, a food that is practically the same as that giving nutriment to the embryo while within the egg.

It is a well-known fact that the food-yolk of the lobster's egg is finally stored in the liver of the growing embryo, and at the time of hatching the supply of this material is nearly exhausted. The liver of the adult lobster, (the greenish-colored gland, so delicious to the taste, and often called the "fat,") is made up of a number of short fibres, which may be readily cut up into morsels practically microscopic. These float about in the water and are easily devoured by the fry, a single liver being sufficient to feed many thousands. As soon as the lobsters leave the hatching-jars, they are placed in Chester jars, the water of which is kept in active movement, and a small quantity of the subdivided liver is added. In a short time the lobsters appear to have changed in color, but a more careful examination will show that the change is only apparent, and not real. It is due to the presence within the stomach and intestine of the yellow-fat-bearing food, which can be seen easily through the transparent body-walls, and which often marks out the shape and extent of the entire alimentary tract. So characteristically does it mark the animals that have fed that they may be removed from their less active, injured, sluggish, or indifferent companions, and placed where they will have more room and a more natural environment than the whirl of the hatchery.

It is our opinion that, thus artificially fed, the young are not so prone to feed upon one another as those starved into cannibalism, and we feel convinced that the food is a determining factor in the problem of brooding.

We have found that the most suitable enclosure is a car, not with rigid walls of wood, wire, or scrim, but rather a large bag of scrim made after the fashion of a fish-pocket, and hanging down into the water from a square floating frame. The bag waves back and forth in the current, giving a gentle motion to the water, and this motion appears to be very essential to the well-being of the larvæ, for without it they settle to the bottom and slowly die.

While the larvæ are in the scrim enclosures, they may be fed with the lobster liver, but this is likely to pollute the water, and, gathering on the upper portion of the scrim, rapidly decays. It is here that the scrim-bags again prove their fitness for this work, for it is a very simple matter to "purse" them up, and gently lead the young into a clean bag, without handling them, and without injuring them in any way. The frequent change from soiled to clean scrim enclosures appears to be essential to the well-being of the young, and is to be recommended for reasons of economy; since the scrim rots if allowed to remain a long time in the sea-water.

Later in the season we found that the older fry appeared to flourish better on living than on prepared food. The living food is doubtless much more natural for them than the finely subdivided liver, and it is certainly much more cleanly. It would of course be very satisfactory if we could find the young of some fish which we could raise in the hatchery, and then liberate in the scrim-bags, the young lobsters catching such as they desired and leaving the others alive until they too were needed for food. In this connection, the young of the goose-fish gave us some encouragement, but they are colored with black blotches, and this color seems not to attract the young lobsters. This indifference of the young lobsters was a disappointment, for the spawn of the goose-fish can be gotten by the tub-ful. It readily hatches in the laboratory, and the young flourish in the scrim enclosures.

But it is not a difficult matter, although a somewhat irksome task, to skim a sufficient quantity of copepods and other surface material to provide an abundance of natural food for the young lobsters. At a certain time of the day, or at certain times of the tide, the plankton (the small floating organisms of the ocean) come to the surface, and a boy with a skimming-net and a boat can soon collect enough to feed thousands of fry. The net is simply drawn through the water and occasionally hauled in, turned inside out, and rinsed in a bucket of sea-water. The rinsings contain myriads of minute organisms, which, poured into the scrim enclosures, are eagerly devoured by the young lobsters.

By the methods above described, and after many failures, accidents, and reverses, we succeeded in raising several hundred lobsters up to the fourth moult, at which time, as previously mentioned, they take on many of the habits of the adult, and have, for their general resemblance to the adult, been called lobsterlings.

Although artificial lobster-culture has been attempted in other countries, we think the efforts of last summer were far more successful than any heretofore reported, and we are encouraged that at no far-distant date we shall be able to report on a successful and practical method of lobster-culture.

The interest attached to the Woods Hole experiments induced your Commissioners to report the results of their work at the meeting of the American Fisheries Association in June, and some idea of the endurance of the lobsterlings when properly nourished may be gained from the fact that during the extremely hot weather a number of these were carried from Woods Hole to Niagara Falls, where they remained without change of water during the meeting, and were then taken back to Woods Hole and again liberated, only a very few individuals perishing on the journey.

12. Distribution of Lobster-Fry.

Your Commission has received upwards of a million lobster fry from the Government hatchery at Woods Hole, and has distributed these in the waters of Narragansett Bay.

13. The Preparation of a List of the Fishes Known to Inhabit the Bay.

Your Commission is often in receipt of strange fishes taken in traps, washed ashore, or captured by hook and line. These have been preserved, and now form the nucleus of a collection. A list of the fishes known to inhabit the waters of Narragansett Bay has never been published, and the following list has been drawn up for the convenience of those who may be interested in the fish fauna of the State. It is based upon data now in the possession of the Commission, and it is our intention to publish a more extensive paper at some subsequent time. Any facts relative to the subject will be gladly received.

PETROMYZONIDÆ. The Lampreys.

Petromyzon marinus (Linnæus). *Great Sea Lamprey; Lamprey Eel.*

GALEIDÆ. The Requiem Sharks.

Mustelus canis (Mitchell). *Smooth Dogfish; Dogfish; Switchtail.*
Carcharhinus obscurus (Le Sueur). *Dusky Shark; Shovel-nose.*

SPHYRNIDÆ. The Hammer-headed Sharks.

Sphyrna zygæna (Linnæus). *Hammer-headed Shark; Hammerhead.*

ALOPIDÆ. The Thresher Sharks.

Alopias vulpes (Gmelin). *Thresher; Thrasher; Swingle-tail.*

CARCHARIDÆ. The Sand Sharks.

Carcharias littoralis (Mitchill). *Sand Shark.*

LAMNIDÆ. The Mackerel Sharks.

Isurus dekayi (Gill). *Mackerel Shark.*

SQUALIDÆ. The Dog-Fishes,

Squalus acanthias (Linnæus). *Dog-fish; Horned Dog-fish.*

RAJIDÆ. The Skates.

Raja erinacea (Mitchill). *Summer Skate; Bonnet Skate.*
Raja ocellata (Mitchill). *Big Skate; Winter Skate.*
Raja lævis (Mitchill). *Barndoor Skate.*

NARCOBATIDÆ. The Electric Rays.

Tetranarce occidentalis (Storer). *Torpedo; Crampfish.*

DASYATIDÆ, The Stingrays.

Dasyatis centrura (Mitchill). *Sting Ray.*

MYLIOBATIDÆ. THE EAGLE RAYS.

Rhinoptera bonasus (Mitchill). *Cow-nosed Ray; Sting Ray.*

ACIPENSERIDÆ. THE STURGEONS.

Acipenser sturio (Linnæus). *Sturgeon.*

SILURIDÆ. THE CAT-FISHES.

Galeichthys felis (Linnæus). *Sea Cat-fish.*

ANGUILLIDÆ. THE TRUE EELS.

Anguilla chrysypa (Rafinesque). *Eel.*

LEPTOCEPHALIDÆ. THE CONGER EELS.

Leptocephalus conger (Linnæus). *Conger Eel.*

ELOPIDÆ. THE TARPONS.

Tarpon atlanticus (Cuvier & Valenciennes). *Tarpon.*
Elops saurus (Linnæus). *Ten-pounder ; Big-eyed Herring.*

CLUPEIDÆ. THE HERRINGS.

Clupea harengus (Linnæus). *Sea Herring; Herring: Sperling.*
Pomolobus mediocris (Mitchill). *Hickory Shad.*
Pomolobus pseudoharengus (Wilson). *River Herring; Alewife.*
Alosa sapidissima (Wilson). *Shad.*
Opisthonema oglinum (Le Sueur). *Thread Herring.*
Brevoortia tyrannus (Latrobe). *Menhaden; Pogy.*

ENGRAULIDIDÆ. THE ANCHOVIES.

Stolephorus brownii (Gmelin). *Striped Anchovy; Anchovy.*
Stolephorus mitchilli (Cuvier & Valenciennes). *Anchovy.*

SALMONIDÆ. THE SALMON FAMILY.

Salmo salar (Linnæus). *Salmon.*
Salvelinus fontinalis (Mitchill). *Brook Trout; Speckled Trout.*

ARGENTINIDÆ. THE SMELTS.

Osmerus mordax (Mitchill). *Smelt.*

SYNODONTIDÆ. THE LIZARD-FISHES.

Synodus fœtens (Linnæus). *Lizard-Fish.*

PŒCILIIDÆ. The Killifishes.

Fundulus majalis (Walbaum). *Mayfish; Killifish.*
Fundulus heteroclitus (Linnæus). *Common Killifish; Mummichog.*
Fundulus diaphanus (Le Sueur). *Spring Minnow; Killifish.*

ESOCIDÆ. The Needle-Fishes and Gar-Foshes.

Tylosurus marinus (Walbaum). *Garfish; Billfish; Bill Eel.*

HEMIRAMPHIDÆ. The Halfbeaks.

Hyporhamphus roberti (Cuvier & Valenciennes). *Halfbeak; Skipper.*

SCOMBERESOCIDÆ. The Sauries.

Scomberesox saurus (Walbaum). *Saury; Skipper; Billfish.*

GASTEROSTEIDÆ. The Sticklebacks.

Gasterosteus bispinosus (Walbaum). *Two-spined Stickleback.*
Apeltes quadracus (Mitchill). *Four-spined Stickleback.*

FISTULARIIDÆ. The Cornet-Fishes.

Fistularia tabacaria (Linnæus). *Trumpet-fish.*

SYNGNATHIDÆ. The Pipe-Fishes.

Siphostoma fuscum (Storer). *Pipe-fish.*

HIPPOCAMPIDÆ. The Sea-Horses.

Hippocampus hudsonius (De Kay). *Sea-horse.*

ATHERINIDÆ. The Silversides.

Menidia gracilis (Günther). *Silverside.*
Menidia notata (Mitchill). *Silverside. Brit.*

MUGILIDÆ. The Mullets.

Mugil cephalus (Linnæus). *Striped Mullet; Jumping Mullet.*
Mugil curema (Cuvier & Valenciennes). *White Mullet.*

SPHYRÆNIDÆ. The Barracudas.

Sphyræna guachancho (Cuvier & Valenciennes). *Barracuda.*

AMMODYTIDÆ. The Sand Launces.

Ammodytes americanus (DeKay). *Sand Launce; Lant; Sand Eel.*

SCOMBRIDÆ. The Mackerels.

Scomber scombrus (Linnæus). *Common Mackerel.*
Auxis thazard (Lacépède). *Frigate Mackerel; Bonito; Tunny.*
Thunnus thynnus (Linnæus). *Horse Mackerel; Tunny.*
Sarda Sarda (Bloch). *Bonito.*
Scomberomorus maculatus (Mitchill). *Spanish Mackerel.*
Scomberomorus regalis (Bloch). *Kingfish; Cero.*

TRICHIURIDÆ. The Cutlas-Fishes.

Trichiurus lepturus (Linnæus). *Cutlas-Fish; Scabbard-Fish.*

ISTIOPHORIDÆ. The Sail-Fishes.

Tetrapterus imperator (Bloch and Schneider). *Spearfish.*

XIPHIIDÆ. The Sword-Fishes.

Xiphias gladius (Linnæus). *Sword-fish.*

CARANGIDÆ. The Pompanos, Crevallés, Amber-Fishes, Etc.

Naucrates ductor (Linnæus). *Pilot-Fish.*
Seriola zonata (Mitchill). *Shark-pilot; Rudder-fish; Pilot-fish.*
Seriola lalandi (Cuvier and Valenciennes). *Amber-fish.*
Decapterus punctatus (Agassiz). *Round Robin; Scad; Cigar-fish.*
Decapterus macarellus (Cuvier and Valenciennes). *Mackerel Scad.*
Trachurops crumenopthalmus (Bloch). *Goggler; Big-eyed Scad.*
Alectis ciliaris (Bloch). *Gobbler-fish; Threadfish.*
Vomer setipinnis (Mitchill). *Horse-fish; Dollar-fish.*
Selene vomer (Linnæus). *Lookdown; Dollar-fish.*
Trachinotus falcatus (Linnæus). *Round Pompano.*
Trachinotus carolinus (Linnæus). *Common Pompano.*

POMATOMIDÆ. The Blue-Fishes.

Pomatomus saltatrix (Linnæus). *Blue-Fish.*

NOMEIDÆ. The Nomeids.

Nomeus gronovii (Gmelin). *Portuguese Man-of-War-Fish.*

CENTROLOPHIDÆ. The Rudder-Fishes.

Palinurichthys perciformis (Mitchill.) *Rudder-Fish; Polefish.*

STROMATEIDÆ. The Butter-Fishes.

Rhombus paru (Linnæus). *Harvest-Fish; Long-finned Butter-Fish.*
Rhombus triacanthus (Peck). *Butter-Fish.*

SERRANIDÆ. The Sea Basses.

Roccus lineatus (Bloch). *Striped Bass; Rockfish.*
Morone americana (Gmelin). *White Perch.*
Epinephelus niveatus (Cuvier & Valenciennes). *Snowy Grouper.*
Centropristes striatus (Linnæus). *Sea Bass; Black Bass.*

LOBOTIDÆ. The Triple-Tails.

Lobotes surinamensis (Bloch). *Flasher; Triple-Tail.*

SPARIDÆ. The Porgies.

Stenotomus chrysops (Linnæus). *Scup; Porgy; Scuppaug.*
Lagodon rhomboides (Linnæus). *Sailor's Choice; Pinfish.*
Archosargus probatocephalus (Walbaum). *Sheepshead.*

SCIÆNIDÆ. The Drums.

Cynoscion regalis (Bloch & Schneider). *Weakfish; Squeteague.*
Leiostomus xanthurus (Lacépède). *Spot; Goody.*
Menticirrhus saxatilis (Bloch & Schneider). *Kingfish; Sea-Mink.*
Pogonias cromis (Linnæus). *Drum.*

LABRIDÆ. The Wrasse-Fishes.

Tautogolabrus adspersus (Walbaum). *Cunner; Chogset.*
Tautoga onitis (Linnæus). *Tautog; Blackfish.*

BALISTIDÆ. The Trigger-Fishes.

Balistes powelli (Cope). *Powell's Filefish.*
Balistes carolinensis (Gmelin). *Trigger-Fish; Leather-Jacket.*

MONACANTHIDÆ. The File-Fishes.

Monacanthus hispidus (Linnæus). *Foolfish; Filefish.*

OSTRACIIDÆ. The Trunk-Fishes.

Lactophrys trigonus (Linnæus). *Trunkfish; Shellfish.*

TETRAODONTIDÆ. The Puffers.

Lagocephalus lævigatus (Linnæus). *Smooth Puffer; Puffer.*
Spheroides maculatus (Bloch & Schneider). *Swellfish; Puffer.*

DIODONTIDÆ. The Porcupine-Fishes.

Chilcomyterus schœpfi (Walbaum). *Swell-Toad; Puffer.*

MOLIDÆ. The Head-Fishes.

Mola mola (Linnæus). *Sunfish.*

COTTIDÆ. The Sculpins.

Acanthocottus æneus (Mitchill). *Little Sculpin; Grubby.*
Acanthocottus grœnlandicus (Cuvier and Valenciennes). *Sculpin.*
Hemitripterus americanus (Gmelin). *Sea Raven; Red Sculpin.*

CYCLOPTERIDÆ. The Lump-Suckers.

Cyclopterus lumpus (Linnæus). *Lumpfish.*

BATRACHOIDIDÆ. The Toad-Fishes.

Opsanus tau (Linnæus). *Toadfish; Toad-Grunter.*

XIPHIDIIDÆ.

Pholis gunnellus (Linnæus). *Butter-fish; Rock Eel.*

ANARHICHADIDÆ. The Wolf-Fishes.

Anarhichas lupus (Linnæus). *Wolf-fish; Catfish.*

ZOARCIDÆ.

Zoarces anguillaris (Peck). *Eel-pout; Sea Eel.*
Lycodes reticulatus (Reinhardt). *Eel-pout.*

TRIGLIDÆ. The Gurnards.

Prionotus carolinus (Linnæus). *Common Gurnard; Sea-robin.*
Prionotus strigatus (Cuiver and Valenciennes). *Sea-robin; Red Sculpin.*

CEPHALACANTHIDÆ. The Flying Gurnards.

Cephalacanthus volitans (Linnæus). *Flying-robin; Flying Gurnard.*

ECHENEIDIDÆ. The Remorus.

Echeneis naucrates (Linnæus). *Shark Sucker; Remora.*
Rhombochirus osteochir (Cuvier). *Spearfish; Remora.*

MERLUCCIIDÆ. The Hakes.

Merluccius bilinearis (Mitchill). *Silver Hake; Whiting; Frostfish.*

GADIDÆ. The Cods.

Pollachius virens (Linnæus). *Pollock.*
Microgadus tomcod (Walbaum). *Tomcod; Frostfish.*
Gadus callarias (Linnæus). *Cod.*

Melanogrammus æglifinus (Linnæus). *Haddock.*
Phycis tenuis (Mitchill). *Squirrel Hake; White Hake; Hake.*
Phycis chuss (Walbaum). *Hake.*
Brosmius brosme (Müller). *Cusk; Ling.*

PLEURONECTIDÆ. THE FLOUNDERS.

Paralichthys dentatus (Linnæus). *Summer Flounder; Flounder.*
Paralichthys oblongus (Mitchill). *Four-spotted Flounder; Flounder.*
Bothus maculatus (Mitchill). *Sand-dab; Window-Pane.*
Limanda ferruginea (Storer). *Rusty Flatfish.*
Pseudopleuronectes americanus (Walbaum). *Flatfish.*

SOLEIDÆ. THE SOLES.

Achirus fasciatus (Lacépède.) *Sole; Hog-Choker; Black Flatfish.*

LOPHIIDÆ. THE FISHING-FROGS.

Lophius piscatorius (Linnæus). *Goosefish; Angler; Fishing-Frog.*

FRESH-WATER FISHES.

Catostomus commersonii (Lacépède). *Brook Sucker.*
Abramis crysoleucas (Mitchill). *Golden Shiner; Roach; Dace.*
Notropis cornutus (Mitchill). *Shiner; Red-fin.*
Lucius americanus (Gmelin). *Banded Pickerel.*
Perca flavescens (Mitchill). *Yellow Perch.*
Ameiurus nebulosus (LeSueur). *Horned Pout; Bullhead.*
Boleosoma nigrum olmstedi (Storer). *Darter.*
Eupomotis gibbosus (Linnæus). *Sunfish.*
Micropterus dolomieu (Lacépède). *Small-mouth Black Bass.*
Erimyzon sucetta (Lac). *Chub Sucker.*
Rhinichthys atronasus (Mitchill). *Black-nosed Dace.*
Lepomis auritus (Linnæus). *Long-eared Sunfish.*

14. A LIST OF THE DIATOMS FOUND IN THE WATER OVER THE CLAM, MUSSEL, AND OYSTER BEDS.

The food of the various shell-fish is composed very largely of diatoms, and localities abounding in natural sets of clams and oysters are generally rich in diatomaceous material. It is obvious therefore that before one can predict the adaptability of any locality to clam or oyster culture, some knowledge of the amount of diatomaceous food present is quite essential. The Commission is under obligations to Messrs. Henry Lothrop and Norman N. Mason for the following carefuly prepared list of diatoms from skimmings made at Wickford during July, 1899.

RAPHIDIEÆ.

FAMILY 1. CYMBELLEÆ.

Amphora commutata.
" excisa.
" formosa.
" incurva.
" laevissima.
" lanceolata.
" lineata.

Amphora maxima.
" minutissima.
" obtusa.
" ovalis.
" recta.
" veneta.
Cymbella lanceolata.

FAMILY 2. NAVICULEÆ.

Mastogloia apiculata.
" exigua.
Stauroneis acuta.
" apiculata.
" oblonga.
" Phœnicenteron.
" producta.
" pulchella.
" salina.
Navicula abrupta.
" ambigua.
" Americana.
" anceps.
" apis.
" Bombus.
" borealis.
" cardinalis.
" columnaris.
" cryptocephala.

Navicula didyma.
" diffluens.
" elegans.
" elliptica.
" forcipata.
" gibba.
" gracialis.
" granulata.
" humerosa.
" impressa.
" lanceolata; var. curta.
" latissima.
" Liburnica.
" longa.
" lyra.
" macra.
" maculata.
" marina.
" Menisculus; var. peregrina.

Navicula mesolepta.
“ ovata.
“ peregrina.
“ praetexta.
“ producta.
“ pusilla.
“ radiosa.
“ retusa.
“ Smithii.
“ splendida.
“ viridis.
“ viridis; var. commutata.
“ sp.? very coarsely marked.
Pinularia fortis of Gregory.
Pleurosigma angulatum; var. aestuarii.
“ Balticum.
“ decorum.
“ elongatum.
“ Fasciola.
Pleurosigma rectum.
Schizonema Adriaticum.
“ Americanum.
“ amplius.
“ Smithii.
Plagiotropis gibberula.
Amphiprora alata.
“ conspicua.
“ constricta.
“ elegans.
“ lepidoptera.
“ minor.
“ ornata.
“ paludosa.
“ pulchra.
“ quadrifasciata.
“ sulcata.
“ vitrea.
Rhoicosphenia curvata.
“ setigera.
“ styliformis.

FAMILY 3. GOMPHONEMEÆ.

Gomphonema acuminatum; var. coronata.
Gomphonema capitatum.

FAMILY 4. ACHNANTHEÆ.

Achnanthes longipes.
“ parvula.
Achnanthes subsessilis.

FAMILY 5. COCCONIDEÆ.

Cocconeis amphiceros.
“ coronata.
“ crucifera.
“ interrupta.
“ lineata.
“ molesta.
“ nitida.
Cocconeis pseudomarginata.
“ scutellum.
“ scutellum; var. minutissima.
“ scutellum; var. stauroneiformis.

PSEUDO-RAPHIDIEÆ.

Family 6. Fragilarieæ.

Epithemia Argus.
“ gibberula.
“ granulata.
“ musculus.
“ turgida.
“ zebra.
Eunotia arcus.
“ monodon.
“ pectinalis.
Plagiogramma Gregorianum.
Dimeregramma minus.
“ nanum; var. minus.
Raphoneis amphiceros.
“ cocconeis.
“ capensis.
Asterionella formosa.
Synedra acus.
“ affinis; var. acumenata.
Synedra crystallina.
“ Danica.
“ delicatissima.
“ Gallionii.
“ lanceolata.
“ longissima.
“ pulchella.
“ robusta.
“ ulna.
“ undulata.
Licmophora Anglica.
“ Dalmatica.
“ flabellata.
“ tincta.
Fragilaria virescens.
Denticula elegans.
Diatoma vulgare.

Family 7. Tabellarieæ.

Tabellaria fenestrata.
“ flocculosa.
Grammatophora angulosa.
“ marina.
“ serpentina.
“ subtilissima.
Striatella arcuata.
“ interrupta.
“ unipunctata.
Rhabdonema Adriaticum.
Odontidium Harrisonii.
“ tabellaria.

Family 8. Surirelleæ.

Campyloneis Grevillii.
Cymatopleura campylodiscus.
Surirella cruciata.
“ delicatissima.
“ gemma.
“ minuta.
“ ovalis.
“ ovata.
Campylodiscus Echeneis.
“ ? Resembles Clypeus; A. S. Atlas, Pl. 54, Fig. 7.
Bacillaria socialis.
Nitzschia amphionyx.
“ apiculata.
“ bilobata.

Nitzschia calida.
“ coarctata.
“ communis.
“ constricta.
“ fasciculata.
“ frustulum.
“ Hungarica.
“ longissima.
“ marginulata.
“ marina.

Nitzschia navicularis.
“ panduriformis.
“ paradoxa.
“ plana.
“ puncta.
“ scutellum.
“ sigma.
“ “ var. diminuta.
“ vermicularis.
“ vitrea.

CRYPTO-RAPHIDIEÆ.

FAMILY 9. CHAETOCEREÆ.

Corethron criophillum.
Rhizosolenia Americana.
“ gracealis.
“ setigera.
“ styliformis.
“ sp.?
Syndendrium diadema.
Bacteriastrum furcatum.
“ varians, var. princeps.

Chaetoceros bacillaria.
“ barbatum.
“ boreale.
“ dispar.
“ didymus.
“ monicae; probably a melosira.
“ protuberans.
“ Wighamii.

FAMILY 10. MELOSIREÆ.

Pyxilla boreale.
“ Kittoniana.
Stephanopyxis turris.
Skeletonema costatum.
Melosira numuloides.
“ scalaris.

Melosira sculpta.
“ sulcata.
“ sp.?
Podosira hormoides.
“ maculata.
Goniothecium sp.?

FAMILY 11. BIDDULPHIEÆ.

Eucampia zodiacus.
Biddulphia aurita.
“ pulchella.
“ turgida.
Triceratium alternans.
“ Brightwellii.

Triceratium favus.
“ intricatum.
“ parallelum; var.
“ punctatum.
“ undulatum.

Family 12. Eupodisceæ.

Auliscus caelatus.

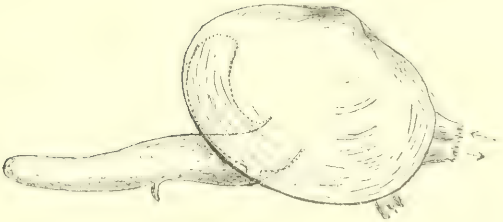
Family 13. Heliopelteæ.

Actinoptychus Grundleri.
Actinoptychus undulatus.

Family 15. Coscinodisceæ.

Craspedodiscus var.
Hyalodiscus subtilis.
Cyclotella compta.
“ stelligera.
“ stricta.
“ sp.?
Actinocyclus crassus.
“ Ralfsii.
Coscinodiscus concavus.
Coscinodiscus concinnus.
“ decipiens.
“ excentricus.
“ heteroporus.
“ patina.
“ radiatus.
“ subtilis.
“ sp.?

PLATE I.



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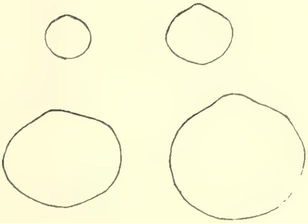

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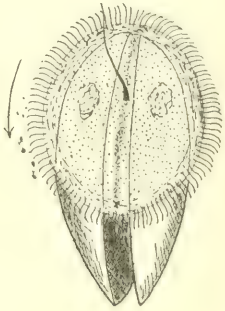

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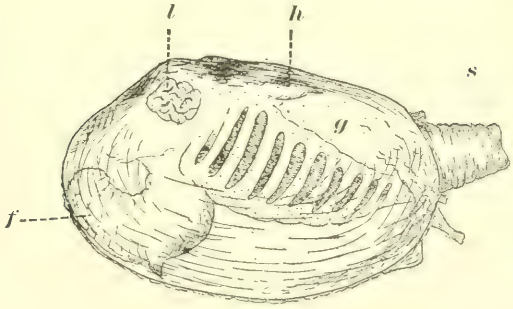

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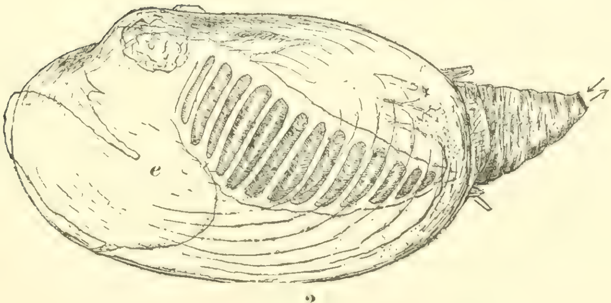

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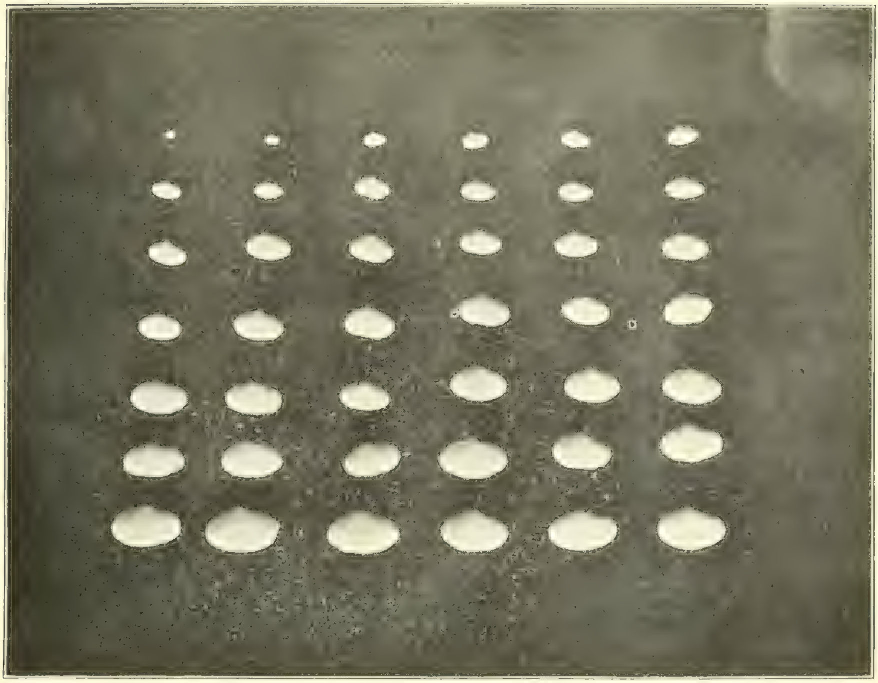

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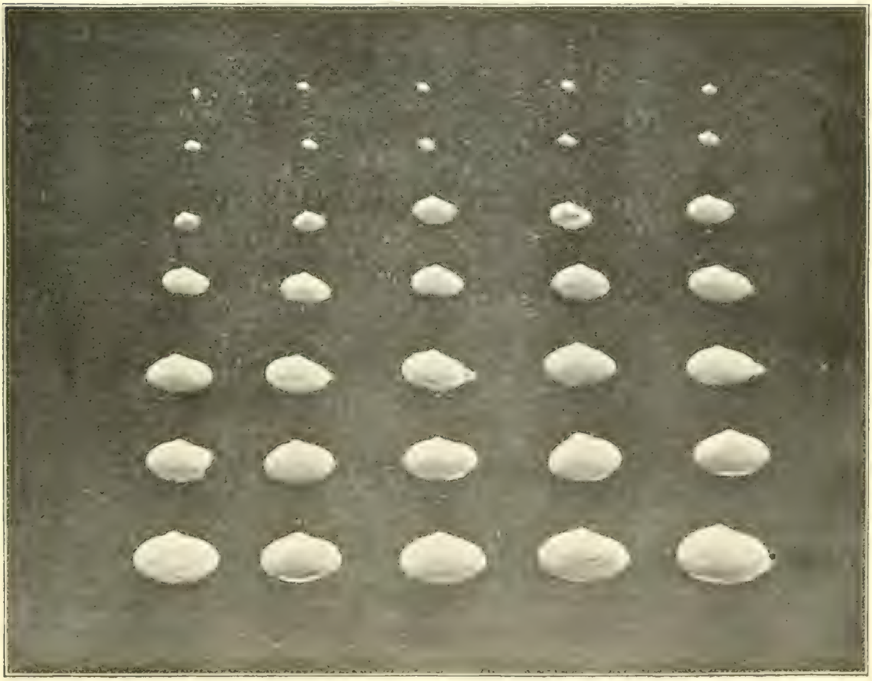

FIG. 7.

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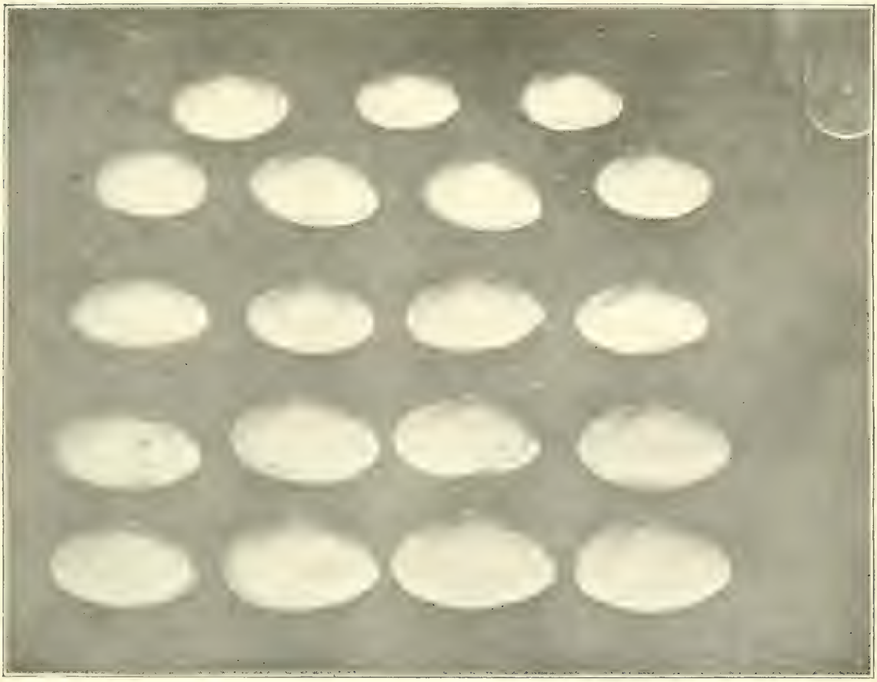

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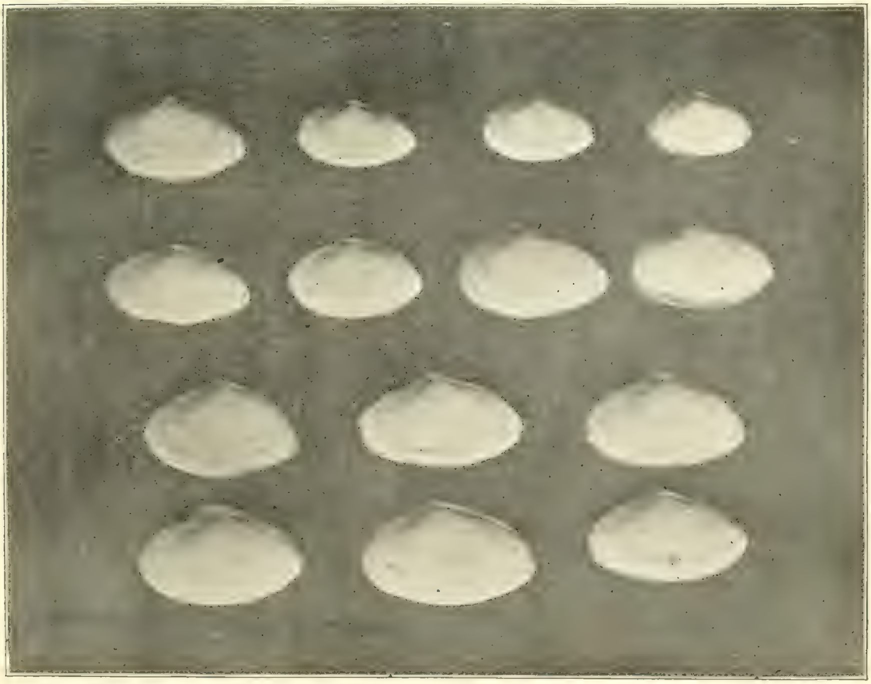

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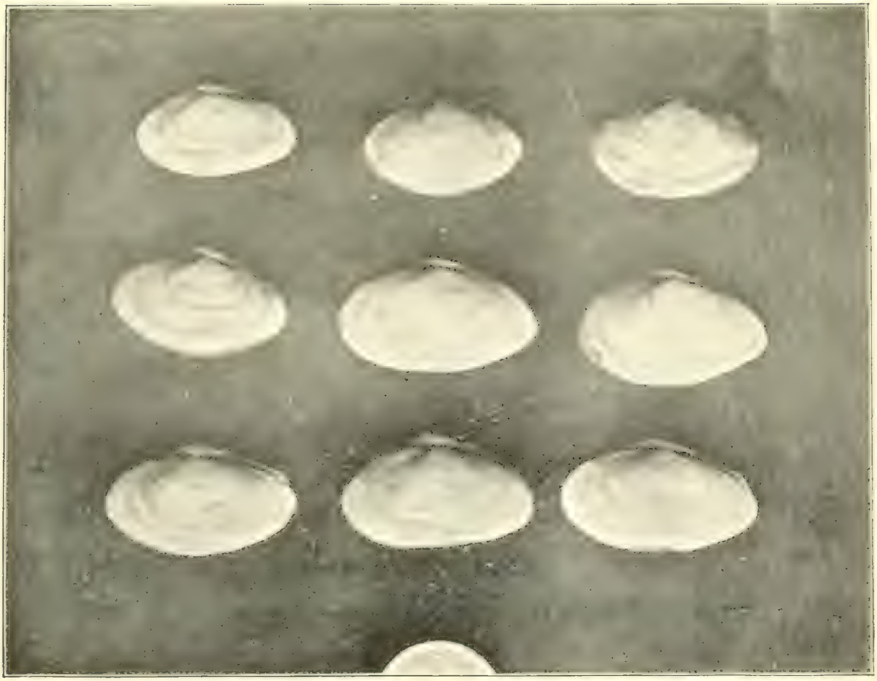

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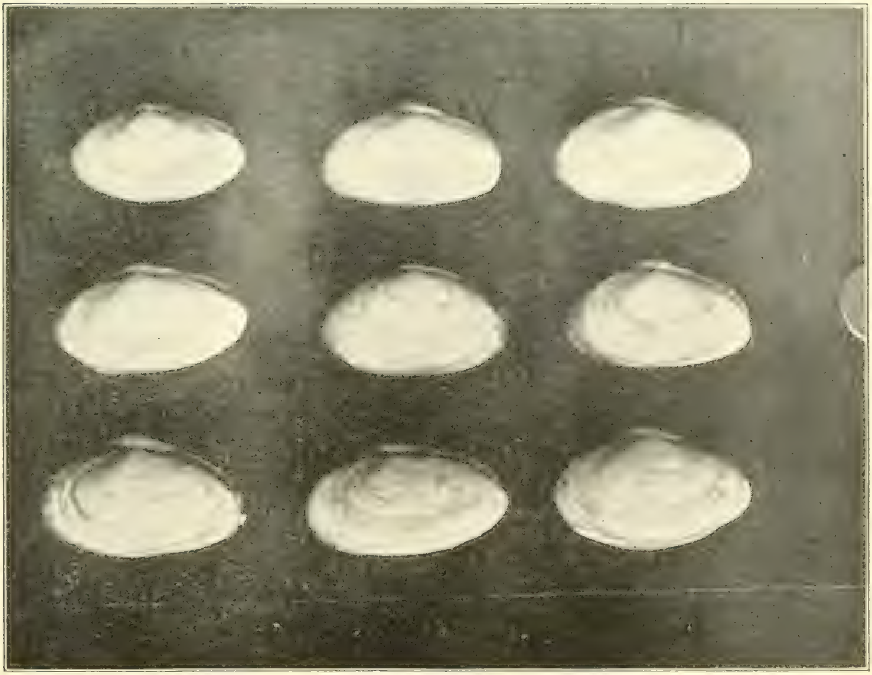

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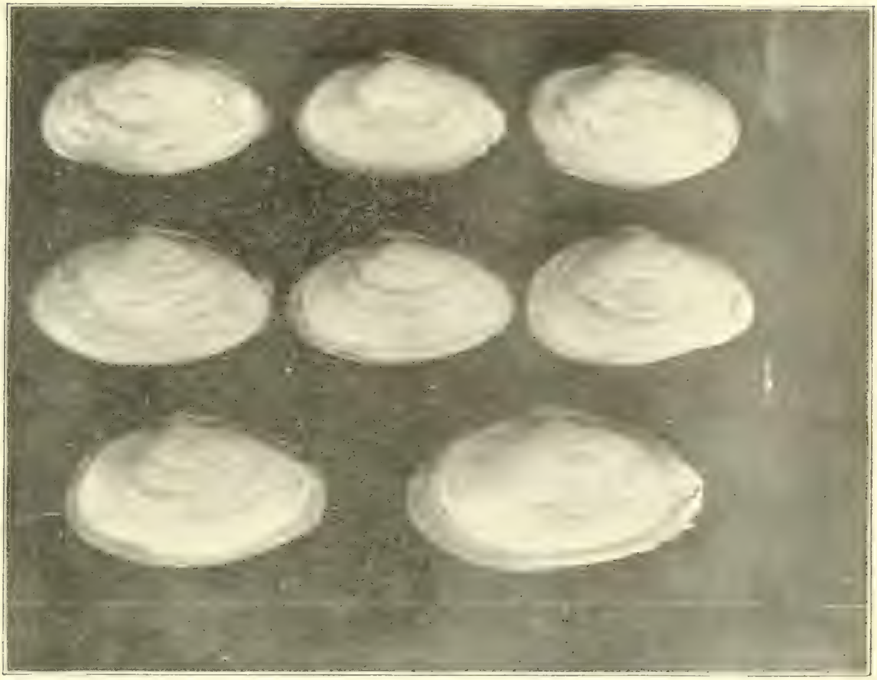

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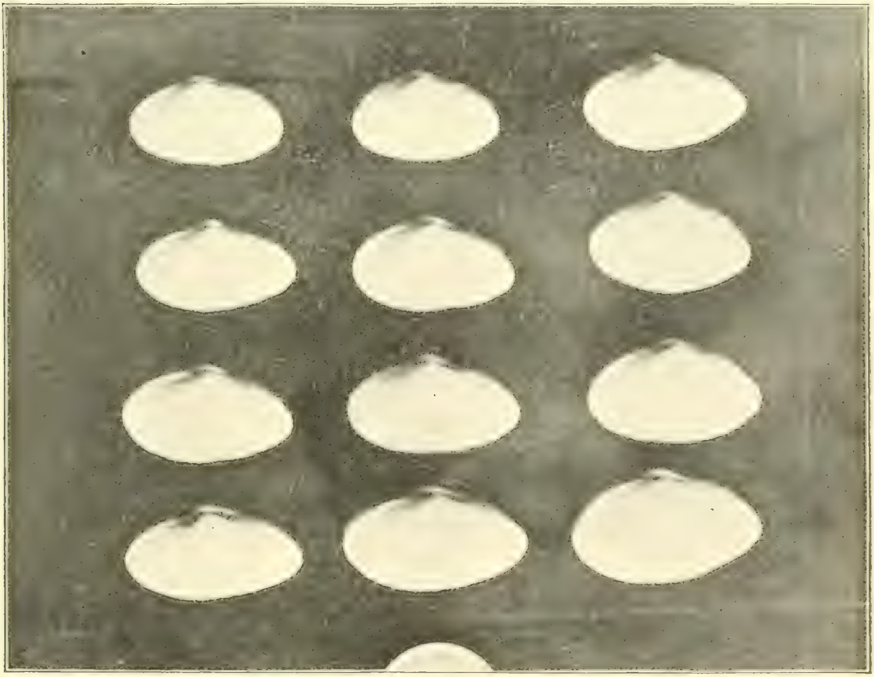

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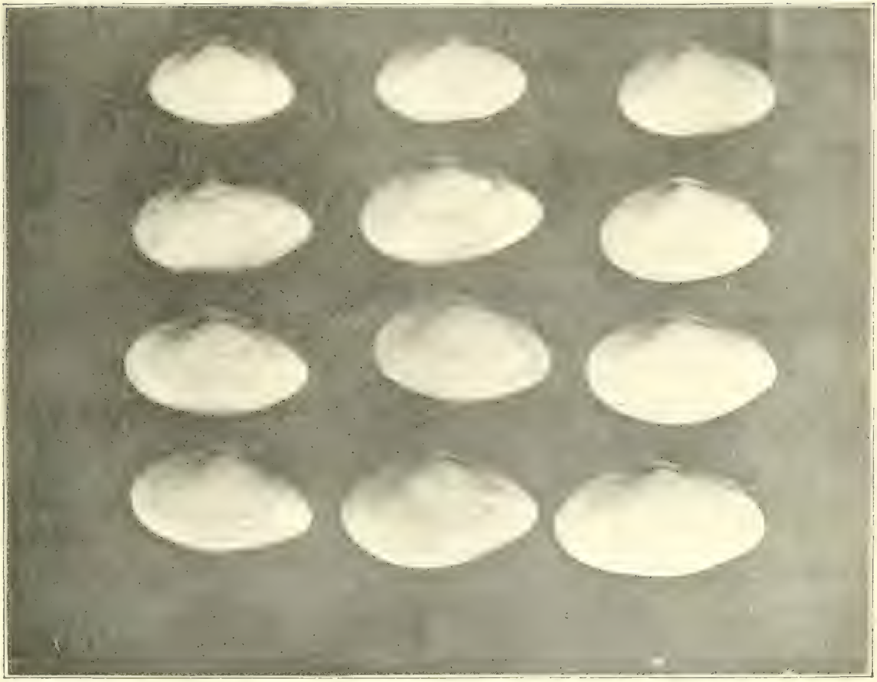

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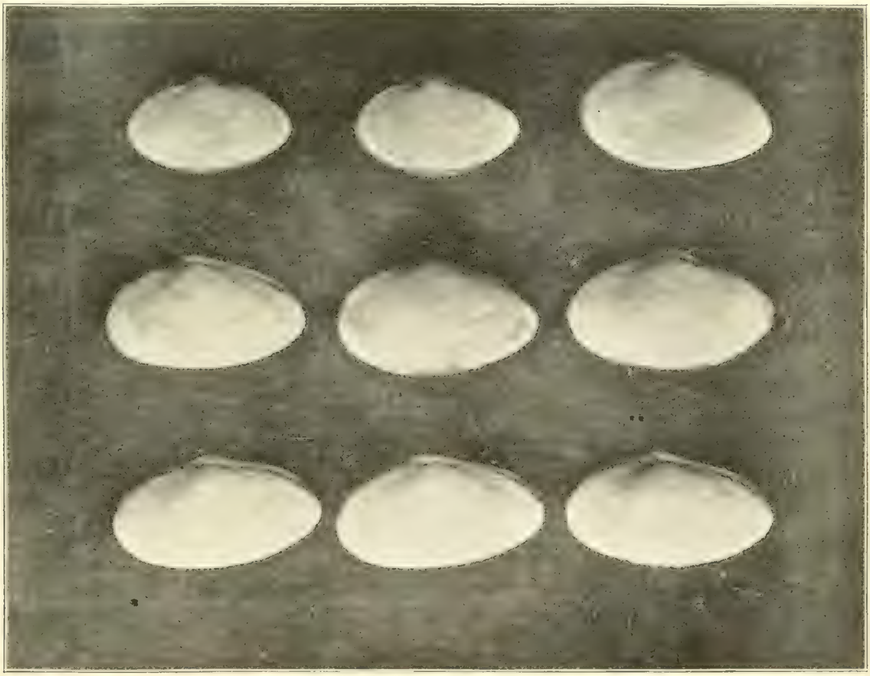

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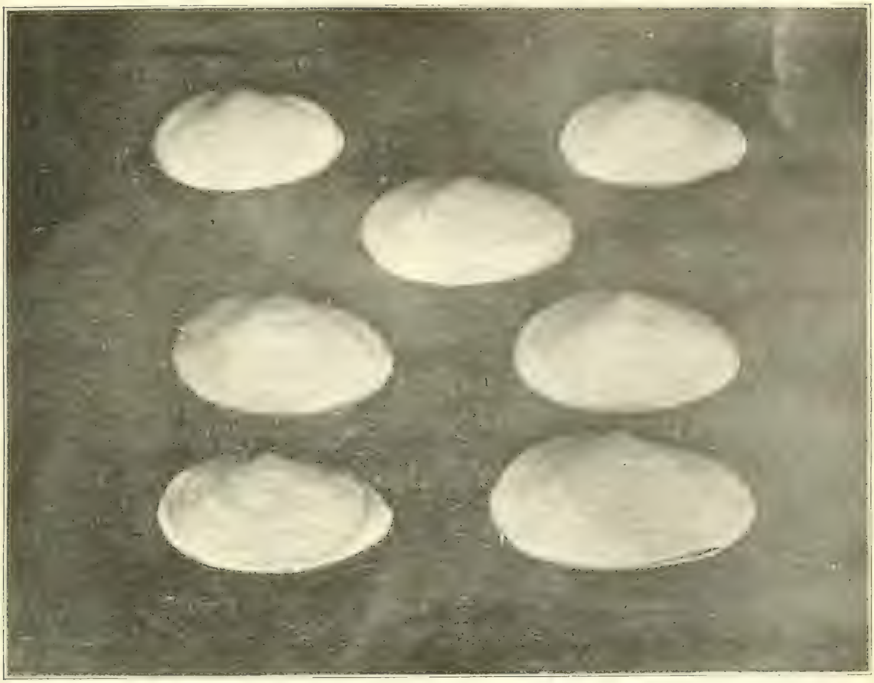

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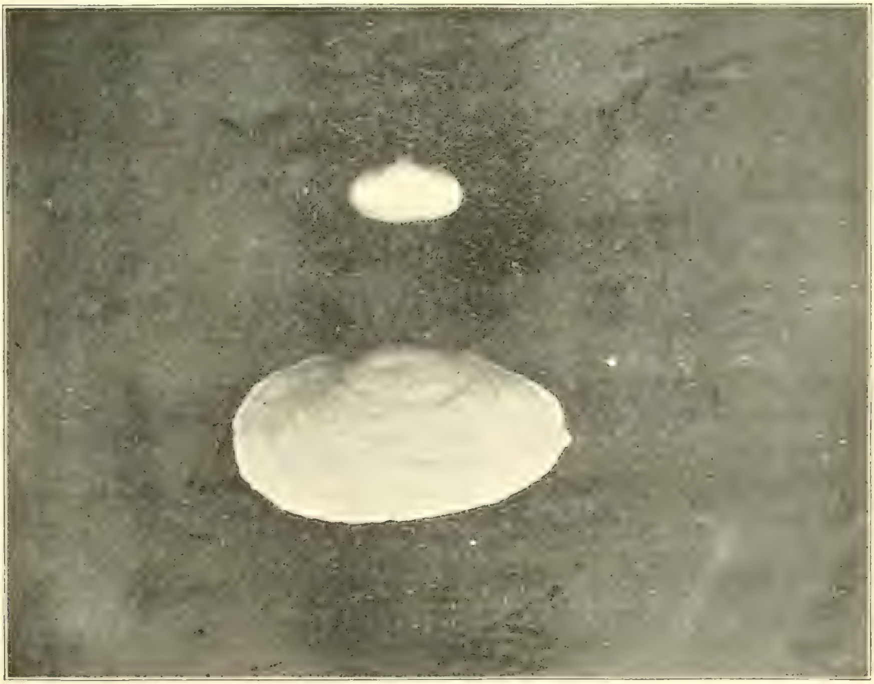

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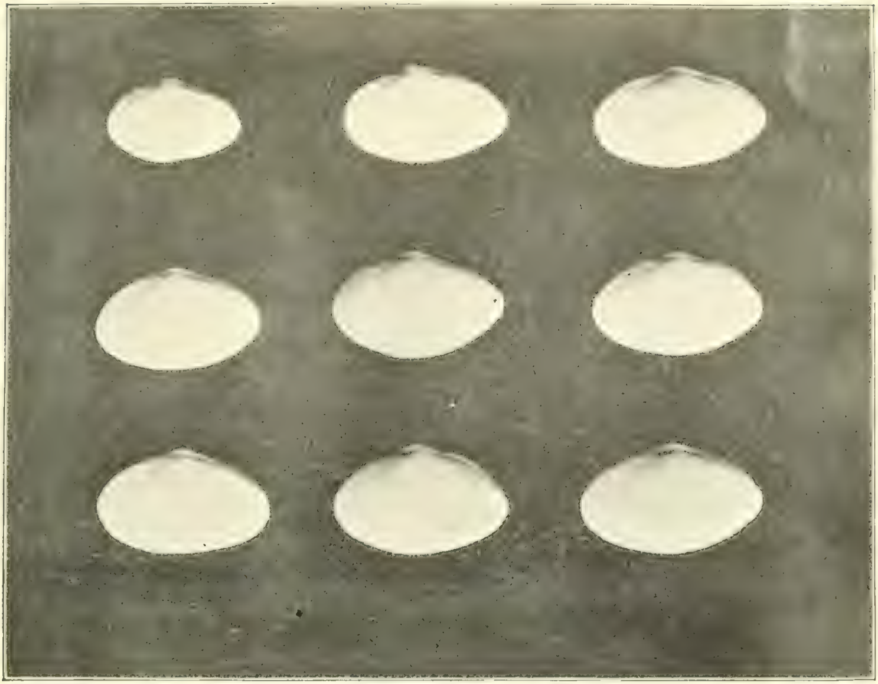

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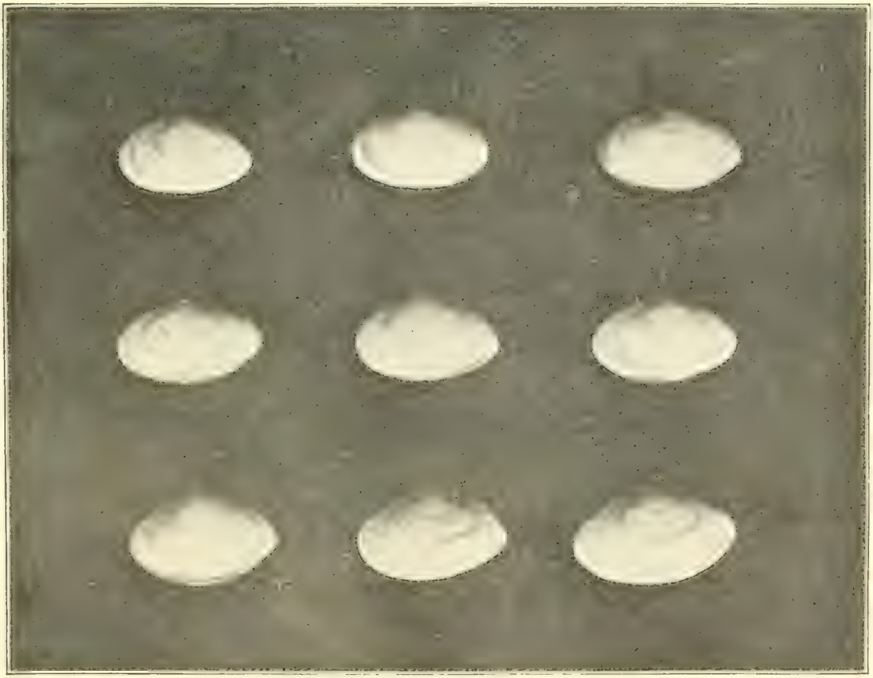
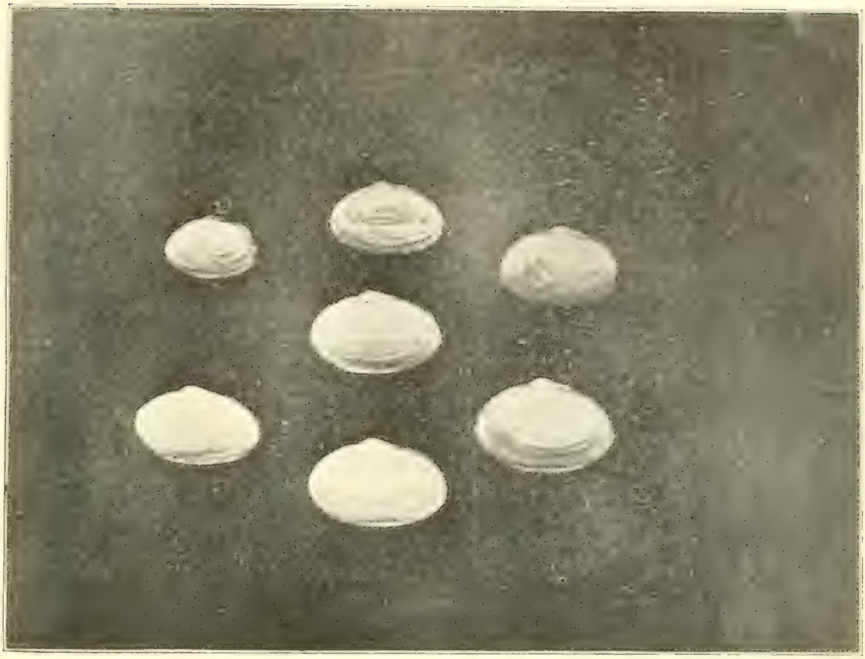


FIG. 21.

PLATE X.



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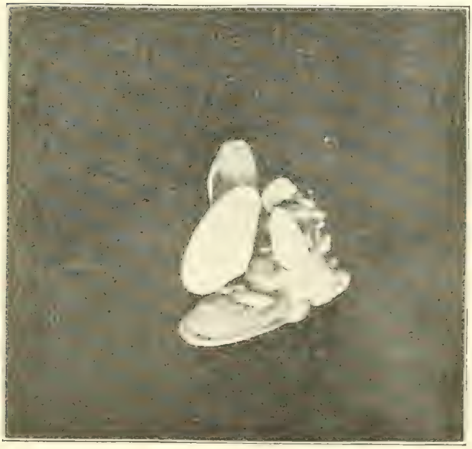

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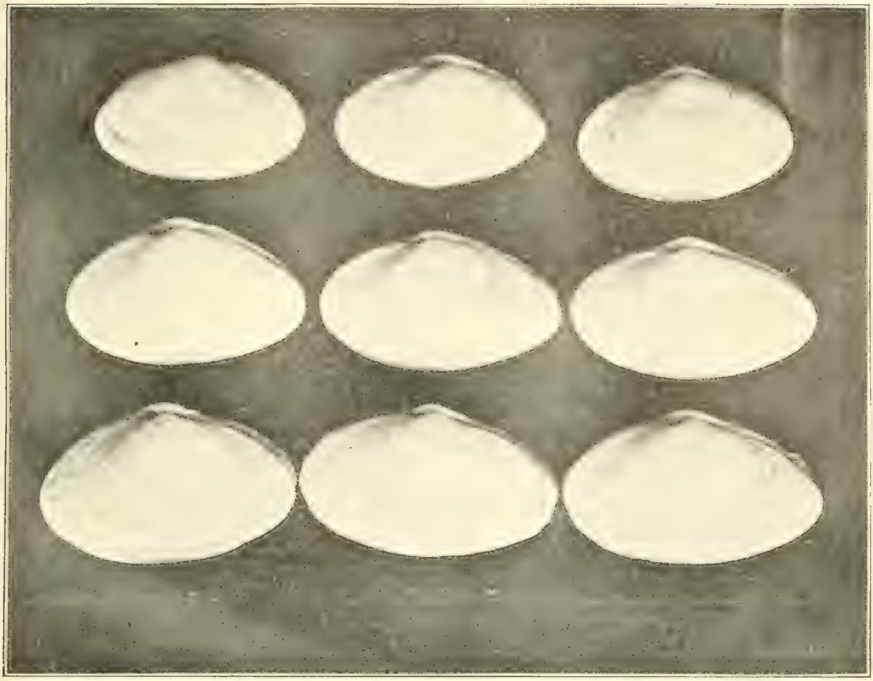

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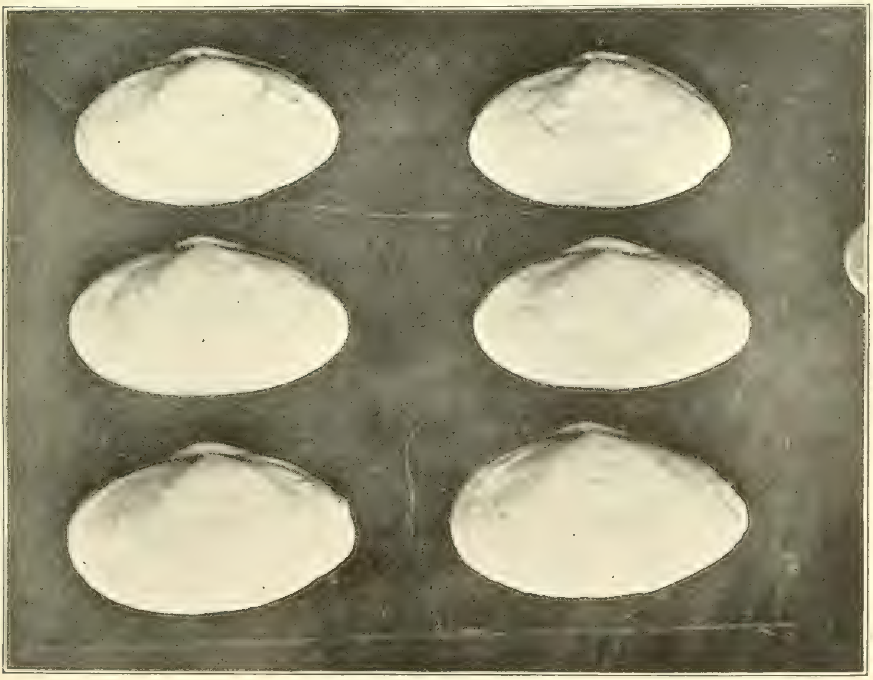

FIG. 25.

3 2044 072 182 165

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